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"To the solid ground
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

THURSDAY, MARCH 4, 1915.

TIME AND SPACE.

A Theory of Time and Space. By A. A. Robb. Pp. vi+373. (Cambridge University Press, 1914.) Price 10*s.* 6*d.* net.

THE appearance of Dr. Robb's treatise, if such a word can be applied to a volume which opens out a new field of philosophical inquiry on the basis of modern physical science, is a very welcome event, and more especially to students of the fundamental nature of the conceptions which we employ in our attempts to describe physical experiences. There is a general feeling, at least in this country, that in spite of the remarkable success of the principle of relativity in simplifying our descriptions of physical science, the more logical aspect of the principle is seriously at fault, and herein lies the reason for the noticeable decline in favour which the principle has experienced recently. The present work, as its title implies, is a definite *theory* of space and time, and although its aim is strictly logical throughout, it deals with its subject in a simple geometrical manner, readily followed by anyone who has made a study of Euclid. The author's selection of a model is very judicious, and makes the argument flow so smoothly that the reader will probably realise with a shock, at some point, the far-reaching nature of the conclusions to which he has been led.

The author had already published the introduction to the work as a tract, but it is reproduced in the present volume. It gives a brief statement of the history and essential meaning of the principle of relativity, pointing out the more important difficulties which are felt, and which the more formal treatises on the principle, by tending to emphasise unduly the purely mathematical aspect, do not attempt to meet. As is well known, relativity demands that events which are simultaneous events for one observer are not necessarily so for another. This is at variance with the fundamental principles of logic, which demand that "a thing cannot both be and not be *at the same time.*" But the simplicity brought about by the introduction of such postulates is such that physicists have allowed them to pass for a time, always, however, realising that our ideas of space, and more especially of time, must be so modified as to make them intelligible and part of a logical system. This simple example will illustrate the scope of Dr. Robb's work, and the exact manner in which it differs fundamentally from the more usual treatises. He has shown that, as a corollary from his treatment of space and time relations, such a logical scheme of geometry and of time can be built up, in which our ordinary geometries find a place.

The foundation of the work involves a new idea —that of *conical order*. The spacial relations are to be regarded as the manifestation of the fact that elements of time, or instants, form a system in conical order. This conception may be analysed in terms of the relations of *after* and *before*. From some twenty-one postulates involving these relations it is possible to set up a system of geometry in which any element can be represented by four co-ordinates, x, y, z, t. The first three correspond to space co-ordinates, and the fourth to time as generally understood. But since an element in this geometry corresponds to an instant, and bears the relations of after and before to other instants, the theory of space appears as a part of the theory of time. Simple geometrical interpretations of the initial postulates in three dimensions are given in the volume. One remarkable feature is that it seems necessary for a really consistent theory to limit the number of dimensions to four. The geo-

metrical system is developed to a considerable extent, and is left at a point from which it may be easily carried in its correspondence with the whole range of ordinary geometrical detail.

The investigation is made in connection with the phenomena of optics. This is, of course, necessary in any attempt to analyse the foundations of any space and time theory. The view taken is that the axioms of geometry are mainly the formal expression of certain optical facts, and the author rightly points out the defects in systems some of the axioms of which have this significance, while others depend on such things as the properties of purely ideal rigid bodies. The significance of all axioms in a logical scheme must be of the same character, and the optical character is the only legitimate one we have at our disposal.

It is not possible in a review to give any account of the detailed working out of these ideas. It can only be said that their development is extremely elegant, and is worthy of being taken as a model for any type of geometrical work. The book is in the standard form of the Cambridge University Press, and bearing in mind the traditional excellence of this series, it is perhaps superfluous to say that the tradition is well maintained in the present case.

APPLIED MECHANICS AND AMERICAN TIMBERS.

The Mechanical Properties of Wood. By Prof. S. J. Record. Pp. vi+165. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1914.) Price 7*s.* 6*d.* net.

TO those unfamiliar with the composition and construction of wood it comes as a matter of surprise that the "hardness," calorific value, also, to some extent, the strength and certain other mechanical qualities, are proportional to the apparent specific gravity. Yet the unexpectedness of these relations vanishes when it is realised that a piece of completely dried wood contains, in addition to air and insignificant amounts of various substances, wood-substance the specific gravity of which is approximately (or truly?) the same in all kinds of woods. Two pieces of dry wood of the same volume thus differ in weight nearly solely because one contains more wood-substance than the other. Wood is not a material, but is a heterogeneous and varied structure, and its particular mechanical properties are dependent not merely on the amount of wood-substance contained in its unit of volume, but also on the manner in which that substance is excavated in the form of strong fibres, weak vessels, and so forth. The arrangement, form, and numbers of these constituents vary widely in different kinds of timbers, with the result that these display corresponding differences in their mechanical properties.

In view of Prof. Record's botanical work on the structure of the woods of the United States, it might have been anticipated that the book under review would deal considerably with the interesting, and incompletely investigated, problems concerning the correlation between the structure and properties of timbers. Very different, however, are the scope and contents of the book, the subject matter of which includes, in order, a brief account of the elementary mechanics of materials, a special consideration of the mechanical properties of wood and of the factors influencing them, and a description of the methods of wood-testing officially adopted in the United States. It gives concise information as to facts gleaned particularly in that country from experiments conducted along the lines laid down by workers in Austria, Germany, and Switzerland; and the information is illustrated by well-chosen figures, including photographs.

The book, however, is akin to a collection of lecture notes dealing with actual experimental results obtained, rather than to a reasoned exposition of the subject. The resultant curtailment is consequently apt at times to lead the student into lack of comprehension or to misconception. The latter is the case when two definitions of hardness are given, the second being "resistance to abrasion or scratching." The truth is that when measured by abrasion the resultant estimates of hardness agree with those obtained by indentation tests and everyday experience with a saw; whereas when tested by scratching all woods are approximately of the same degree of hardness, and that degree is a low one (about equal to muscovite). One feature that takes from the value of the book to English students is that in it, as unfortunately in an increasing number of American scientific books, the language, terminology, and nomenclature are partly foreign to England. Not only are the timbers mentioned exclusively under American names, but popular technical terms unknown in this country are employed, and scientific definitions do not at times accord with those in use here. For instance, a unit stress is defined as "the stress on a unit of sectional area." (Not thus explicable is the erroneous statement on the same page that a "stress-strain diagram" is "a diagram or curve plotted with the increments of load or stress as ordinates, and the increments of strain as abscissæ"; the curve in question supplied shows that the words "increments of" should be omitted.)

In addition to the well-illustrated account of the methods of wood-testing adopted by the U.S. Forest Service, a useful bibliography of the subject, and particularly a list of less-known American papers, gives value to the book. P. G.

WATER REPTILES.

Water Reptiles of the Past and Present. By Prof. S. W. Williston. Pp. vii+251. (Chicago: University of Chicago Press; London: Cambridge University Press, n.d.) Price 12*s.* net.

JUST as it is clear that the existing whales and porpoises are descended from quadrupeds which formerly lived on land, it is gradually being recognised that the marine reptiles which occupied their place during the Secondary Period of geological time also had land-ancestors. Many of the connecting links can now be traced among the fossils discovered during recent years, and so much progress has been made in interpreting them that it is interesting to pause and survey the result. The original papers are scattered through special journals, some of them not easily accessible, and it is necessary to collect the essential facts from numerous sources. We therefore welcome the small book by Prof. Samuel W. Williston, who has devoted many years to the successful study of these reptiles and now reviews the subject exhaustively with first-hand knowledge.

Though the work is mainly suited for students who have some preliminary acquaintance with vertebrate palæontology, Prof. Williston hopes to attract more general readers by a series of introductory chapters dealing with a few elementary geological considerations, and with the structure of the reptilian skeleton and its various modifications in those animals which are adapted for life in water. He then treats the groups of water reptiles in systematic order, referring to the few that survive as well as the great tribes of extinct forms. The descriptions are illustrated both by drawings of the skeletal remains themselves and by many spirited restorations, some original and others by well-known authorities. The technical accounts of structure, indeed, are followed in all cases by a discussion of the inferences they suggest as to the habits and mode of life of the animals in question. All the chapters are well up-to-date, and that on the Cretaceous Mosasauria is especially interesting from its intimate connection with the author's own researches.

As we turn over the pages of this book we are led to speculate as to why nearly all these groups of water reptiles, so widely distributed in every sea, suddenly became extinct at the end of the Secondary Period, without coming in contact with the whales and porpoises which in later times took their place. Prof. Williston can only suggest that the races may have become effete and died of old age. It is evident that the mystery still awaits solution. A. S. W.

MIND AND MATTER.

(1) *The Master-Key: a New Philosophy.* By D. Blair. Pp. 118. (Wimbledon: Ashrama Agency, 1914.) Price 3*s.* 6*d.* net.

(2) *Essays on the Life and Work of Newton.* By A. de Morgan, edited by P. E. B. Jourdain. Pp. xiii+198. (Chicago and London: The Open Court Publishing Co., 1914.) Price 5*s.* net.

(3) *The Analysis of Sensations and the Relation of the Physical to the Psychical.* By Dr. E. Mach. Translated by C. M. Williams. Pp. xv+380. (Chicago and London: The Open Court Publishing Co., 1914.) Price 6*s.* 6*d.* net.

(4) *Proceedings of the Aristotelian Society.* New series, vol. xiv. Pp. 438. (London: Williams and Norgate, 1914.) Price 10*s.* 6*d.* net.

(5) *The Philosophy of Change: a Study of the Fundamental Principle of the Philosophy of Bergson.* By Dr. H. W. Carr. Pp. xii+216. (London: Macmillan and Co., Ltd., 1914.) Price 6*s.* net.

(1) THE writer condemns himself by his own pretensions. He calls his system a "new philosophy," and is writing another book—"The Truth about the Other World"—which "will be the first genuine Revelation ever published." In the volume under notice he discusses all things in heaven and earth, from the solar spectrum, heredity, and space, to Platonism, hallucinations, and Vedanta. There is evidence of a great deal of heterogeneous and elementary knowledge, but all is confused and superficial. Apparently the author finds salvation in the word Monad—though he does not expound Leibniz—but his explanations do not explain much. He posits a "nerve-ether" which is quite different from the luminiferous æther, which latter is "no use" to him; and he seems to have a very poor opinion of the Royal Society. No doubt the society will survive.

(2) These reprinted essays, written more than half-a-century ago, are still worth reading, both for their matter and their style. De Morgan was an able mathematician, he made careful researches into the details of Newton's life and controversies, and he had a very characteristic wit. His treatment of Newton is respectful yet critical. Sir

Isaac was not the almost superhuman moral paragon which for long it was the fashion to suppose him; he had a petulant dislike of opposition, a tendency to keep his discoveries to himself instead of letting the world have the benefit of them —in which he compares badly with the frankness of Leibniz—and a rather mean revengefulness, as in his treatment of Flamsteed, whose observations had been pre-eminently useful to him. On the other hand, De Morgan readily acclaims him as the greatest scientific genius of all time, and indeed above the average level of his time as to character also. His protest is merely against excessive veneration. Section viii. of the last essay is on Newton's religion, which has been the subject of much debate. The Unitarians claim him, and, in spite of Brewster, they are probably right.

There is a small mistake in the footnote on p. 21—"Uranus" should be "Neptune"—but we mention it only in order that it may be put right in the next edition. We see no other slips, and the editor is to be congratulated on a piece of good work.

(3) This book is not so much a new edition of the English translation of Prof. Mach's "Contributions to the Analysis of the Sensations," published in 1897, as an entirely new work; for it is considerably enlarged. Its contentions, however, are the same, and the expansion is in the details. Mach disclaims the title of philosopher, considering himself a physicist; but inasmuch as he seeks a unifying principle applicable to all sciences, he philosophises. According to his view, all experience is made up of elements which are best regarded as of one kind. The distinction of material and psychical, of subject and object, is mischievous. All experience is of one stuff, and the task of science is to investigate relations. A psychical fact is as real as a material fact; indeed, each element exists in both the worlds, according to our purposes of the moment. And as this web of experience—and its threads of relations—is all that we need concern ourselves with, we can throw overboard the *Dinge an sich* which modern philosophy inherits from Kant, and with these useless *noumena* lying behind material phenomena we can throw overboard the *noumenon* which lies or was supposed to lie behind our own mental phenomena.

This radical abolishment of the ego is the main difficulty. Mach counters the inevitable question "*Who* experiences?" by saying that the question itself shows the questioner to be still in the bonds of the fatal habit of subsuming every element (sensation) under an unanalysed complex (p. 26), and this is admittedly a neat and suggestive answer. It does not prove that there is nothing in that complex but its elements and their relations, but, on the other hand, the ego-advocates cannot prove that there is something. J. S. Mill reached this same stalemate, being unable to see how a chain of memories can be conscious of itself. ("Examination of Sir William Hamilton's Philosophy," particularly the chapter on the "Psychological Theory of an External World.") The fact is that we can no more circumnavigate and exhaustively comprehend the totality of our own self, than we can lift ourselves off the ground by pulling at our own bootstraps. It follows from this, and quite harmoniously with Prof. Mach's principles, that our attitude towards possible survival of death should be entirely non-committal, so far as *a priorism* is concerned. He himself decides against it, somewhat vehemently—which perhaps indicates human prejudice overcoming philosophic calm. But he writes for the most part with a saving humour and modesty, and in moments of quiet reflection he would probably admit that his "Weltanschauung" does not necessitate the annihilation of the large complex which is himself, when the portion of that complex which he calls his body is detached.

(4) The Proceedings of the Aristotelian Society are for exceedingly athletic thinkers, and are probably the cause of many headaches even to them. The papers are highly technical, and in so far as they are philosophic rather than scientific, they do not call for detailed review in NATURE. The present volume contains, among other things, the following: "Appearance and Real Existence," by G. Dawes Hicks; "William of Ockham on Universals," by C. Delisle Burns; "Philosophy as the Co-ordination of Science," by H. S. Shelton; "Intuitionalism," by N. O. Lossky; "Discussion —The Value of Logic," by A. Wolf and F. C. S. Schiller; "The Psychology of Dissociated Personality," by W. Leslie MacKenzie (who inclines too much to Münsterberg and Freud, and does not mention F. W. H. Myers); "Freedom," by S. Alexander; "The Status of Sense-Data," by G. E. Moore and G. F. Stout; and "The Principle of Relativity," by H. Wildon Carr, who discusses difficulties about the objectivity of the æther, etc., and finds absolute reality in life or consciousness itself only.

(5) Probably no one can read M. Bergson without feeling the fascination of his style and the persuasiveness of his apt imagery; and the same is true of his chief disciple and expounder in this country. Mr. Carr gives us a sincere and careful account of the new philosophy as he sees it, emphasising its fundamental stress on change, and pointing out that with regard to science it is

neither contemptuous like Hegelianism nor degraded to a servile co-ordinator as in the positivism of Comte and Spencer, but is equal and friendly, bringing a new method of its own for the attainment of further truth. This intuitional method requires a great effort at the outset, he admits; for it involves a turning away from the intellectual methods of the last 2500 years. After reading this book of Mr. Carr's and the whole of M. Bergson's published writings, one reviewer at least feels that while M. Bergson is undoubtedly trying to express what is very real and true to him—and doing it in beautiful language—the thing is difficult and almost impossible, because the philosophy consists of an attitude, so to speak—or of a vividness of personal experience, which is incommunicable. Mr. Carr denies that it is mystical, and, taking some senses of that much-abused word, he is no doubt right; but it is mystical in its anti-conceptualism, and is essentially allied to various Oriental systems. It is a grafting of East on West, including the excellences of both. Perhaps at bottom it is a release from old fetters rather than a new doctrine. A heterodoxy does its chief good not by bringing new truth, but by cancelling out old error, and allowing the mind to go forward unencumbered. J. A. H.

OUR BOOKSHELF.

Panama, the Canal, the Country, and the People. By Arthur Bullard (Albert Edwards). Revised edition. Pp. xiv+601. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1914.) Price 8*s.* 6*d.* net.

MR. BULLARD (Mr. Edwards of the first edition) has brought his sketch of Panama up-to-date by the addition of chapters describing the progress of the canal since 1911. The book consists chiefly of two parts, first a history of the State of Panama, and secondly a very pleasant description of the life of the Americans during the last ten years in the huge construction camp on the canal line. This life was well worth description, being truly a remarkable phenomenon. In the midst of a tropical wilderness, far from their own country, and in a pestilential climate, a labour-camp of fifty thousand hands settled at once to an orderly and civilised life, and, under the protection of a medical despotism, enjoyed on the whole excellent health.

Mr. Bullard provides character sketches of the principal constructors—Colonel Goethals, Colonel Sibert, Doctor Gorgas, and the rest, including Mr. Comber, the dredging expert, who is responsible, under Colonel Goethals, for most of the work now going on. This consists in the removal of the material which comes into the Culebra cut from the breaking ground along a length of about two miles near the deepest part of the excavation. Part of it slides in from above, part of it squeezes up from below under pressure from the sides. It is this latter movement which is so disquieting. In one or two cases ships have gone aground before it was known that there had been an upheaval beneath the opaque and muddy waters of the canal. Some years may elapse before the Culebra cut is stable; meanwhile, the canal is used, though not without interruption, and the whole of the complicated lock machinery works without a hitch.

V. C.

Catalogue of Scientific Papers. Fourth Series. (1884–1900.) Compiled by the Royal Society of London. Vol. xiv. C—Fittig. Pp. 1024. (Cambridge University Press, 1915.) Price 2*l.* 10*s.* net.

THE first volume of the fourth series of the Royal Society's Catalogue of Scientific Papers was noticed in the issue of NATURE for August 20 last. It was pointed out on that occasion that this series comprises the titles of papers published or read during the period 1884–1900, and concludes the work undertaken by the Royal Society. The catalogue thus completed will contain titles of papers for the whole of the nineteenth century. It will be remembered that the continuation of the work is now undertaken by the authorities of the International Catalogue of Scientific Literature.

The present volume contains 24,994 entries of titles of papers by 4351 authors with the initial C, 17,665 entries by 3072 authors with the initial D, 7750 entries by 1368 authors with the initial E, and 6646 entries by 1230 authors under F, as far as Fittig. The total for the first two volumes of the series is 108,775 entries by 18,950 authors.

It is to be hoped that the series of volumes will be added to every reference library of importance throughout the world, so that the public-spirited conduct of the publishers, who have undertaken the complete risk of printing and publishing, may not result in financial loss.

What do We Mean by Education? By Prof. J. Welton. Pp. xii+257. (London: Macmillan and Co., Ltd., 1915.) Price 5*s.* net.

PROF. WELTON'S question has been heard in every direction since the war began; and perhaps the outstanding characteristic of the answers which have been offered is the almost complete disagreement among them. Most competent persons will agree with Prof. Welton that "an investigation into fundamental principles" is necessary before a satisfactory reply to the question can be given. This book undertakes such an inquiry, and certainly the reader who follows the argument to the end will leave the volume with much clearer ideas on the subject. The titles of the chapters indicate the trend of the discussion: "The end rules the means"; "What should be the end?"; "Synthesis of liberty and authority"; "What are the means?"; "Who are the agents?" Though difficult reading in parts, the volume deserves the careful attention of teachers and educational administrators.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Spectra of Hydrogen and Helium.

IN a letter to NATURE of February 11, Prof. J. W. Nicholson discusses the recent interesting experiments of Mr. Evans on the spectrum emitted from a vacuum tube containing highly purified helium and subject to a heavy discharge. Evans found that the 4686 series and the Pickering series can be obtained in a helium spectrum showing no trace of the ordinary hydrogen lines. These series were observed a few years ago by Prof. Fowler by sending a heavy discharge through a mixture of hydrogen and helium; previously they had been observed only in star spectra. In addition, Evans observed that under the same conditions as the 4686 series and the Pickering series a new series of lines appeared, which, with regard to position and intensity, could be united with the Pickering series into a single series of the same type as the 4686 series. The lines of the new series have wave-lengths very close to the hydrogen lines of the Balmer series. In his letter Prof. Nicholson expresses the opinion that Evans's results cannot be used to discriminate between the different theoretical interpretations of the spectra in question, since the new series as well as the Pickering series can be deduced from the 4686 series on the general principle of combination of spectral lines. I cannot agree with this view, and should like here to state my reasons.

According to the theory proposed by Rydberg, and generally accepted for a long time, all the lines in question are ascribed to hydrogen. This theory is based on a supposed analogy between the hydrogen spectrum and the spectra of the alkalies. The Balmer series, the Pickering series, and every second member of the 4686 series are considered as diffuse series, sharp series, and principal series.

According to the theory proposed by the writer, the series spectrum of hydrogen is simply represented by the formula

$$\nu = K\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right), \quad . \quad . \quad . \quad . \quad . \quad (1)$$

including only the Balmer series, the Ritz series in the ultra-red, and the series in the ultra-violet recently observed by Lyman. The other series are all ascribed to helium and represented by the formula:

$$\nu = 4K'\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right), \quad . \quad . \quad . \quad . \quad . \quad (2)$$

including the 4686 series, the Pickering series, and Evans's new series. K' is not exactly equal to K, though very nearly so, the theoretical value for the ratio K'/K being 1·00041. The theory rests upon a certain application of the quantum theory to the theory of the nucleus atom, and essentially involves the combination principle. While the ordinary helium spectrum is supposed to be emitted from a helium atom which has lost a single electron, spectrum (2) is emitted, according to the theory, from a helium atom which has lost both its electrons. If spark spectra result from the removal of two electrons from the atom, formula (2) should correspond to the spark spectrum of helium, while hydrogen, which is supposed to have only one electron in the atom, cannot give a spark spectrum.

Since the numerical relations between the different series claimed by the two theories are not exactly the same, it would be possible at once, as mentioned by Prof. Nicholson, to discriminate between the theories if the wave-lengths of the lines were exactly known. It seems that both the measurements of Fowler and Evans are in close agreement with formula (2), but that it would be difficult to reconcile Evans's redetermination of the wave-length of the Pickering lines with Rydberg's assumption that the Balmer series and the Pickering series have the same limit. Quite apart, however, from the question of the exact numerical relationship between the series, it seems that fundamental difficulties in Rydberg's view are brought to light by the experiments of Fowler and Evans. Fowler's observation that the 4686 series contains twice as many members as the series predicted by Rydberg, and Evans's observation of the new series accompanying the Pickering series, destroy completely the simple analogy with the alkali spectra which forms the basis of Rydberg's theory. If, as Prof. Nicholson proposes, we look upon the Pickering series and the Evans series as a simple combination series deduced from the 4686 series, the contrast with the alkali spectra seems even more striking, since then apparently no sharp series is observed. On the other hand, it will be noticed that this simple relation between the series is an immediate consequence of formula (2), and that Evans's observation makes the representation of this formula more complete than before since only every second member of the series corresponding to $n_1=4$ was previously observed.

I must confess, however, that perhaps the strongest objection to Rydberg's view seems to be the entirely different chemical conditions for the appearance of the Balmer series and the other series, so clearly shown by Evans's experiments. This difference has no analogy in the appearance of the diffuse series in the alkali spectra. I am afraid that it may not seem reasonable to emphasise this objection so strongly, since it, of course, has been contemplated by spectroscopists ever since the theory was proposed, but it appears that the basis for the consideration of this question recently has entirely changed. Rydberg's theory of the hydrogen spectrum offered not only an adequate representation of the evidence at hand at that time, but it was apparently the only way to bring the Pickering series into line with Rydberg's own fundamental investigations on the general relations between spectral series. However, Fowler's recent important work on series in spark spectra has shown that these spectra obey laws of exactly the same character as the ordinary arc spectra, with the only exception that the Rydberg constant is replaced by a constant four times as large. Consequently formula (2) corresponds to the general formula for series in spark spectra exactly as formula (1) corresponds to the general formula for series in arc spectra. It would therefore appear that at present there is scarcely sufficient theoretical evidence to justify us in disregarding the direct evidence as to the chemical origin of the lines given by Evans's experiments.

It may be of interest in this connection to mention that the above conclusions seem to be supported by spectroscopic evidence of an entirely different character. Recently Dr. Rau (*Sitz. Ber. d. Phys. med. Ges. Würzburg*, 1914) has made some interesting experiments on the minimum voltage necessary to produce spectral lines. He finds that about 30 volts are necessary to produce the lines of the ordinary helium spectrum, and that the voltage necessary to produce the different lines and series in this spectrum differ only by a few volts. On the other hand, he finds that the lines of the Balmer series appear with

a voltage of only about 13 volts, while about 80 volts are necessary to produce the lines of the 4686 series and the Pickering series. According to the theory of the writer, the energy necessary to remove the electron from the hydrogen atom corresponds to a fall of an electron through a potential difference of 13·6 volts, while the energy to be used in removing one electron from the helium atom corresponds to a fall of 29·0 volts, and in removing both electrons to a fall of 83·4 volts. N. BOHR.

Physical Laboratory, University of Manchester, February 21.

X-Ray Fluorescence and the Quantum Theory.

THE experimental conclusions which I briefly outlined in a letter to NATURE of February 18 point directly to a theory of X-ray fluorescence and of the emission of radiation in quanta, which certainly bears a resemblance to Bohr's theory of line spectra. The experimental evidence obtained is, however, so direct that there seems little possibility of escape from the conclusions given below. Indeed, the theory was forced upon the writer directly by the experimental results, and it was only afterwards that he was reminded of some similarity with the theory of Bohr based on the Rutherford atom.

It is an experimental fact that in the case carefully investigated (and obviously in many, if not in all, other cases), the ejection from an atom of an electron associated with a fluorescent X-radiation of frequency n necessitates an absorption of energy greater than the kinetic energy carried away by the electron by approximately the energy (hn) of one quantum of radiation of frequency n. Thus :—

(1) Total absorption per electron emitted $= \frac{1}{2}mv^2 + hn$ (approximately)—that is, the energy required to separate the electron (a K electron, say) from the parent atom, is approximately equal to the energy of a quantum of the fluorescent radiation of series K associated with that electron.

The energy of a quantum of radiation may therefore be regarded as the mutual potential energy of the separated atom and electron, measured from the zero given by the electron in its normal position and state. When the displaced or any other electron falls back into the position of the displaced electron, the energy is re-emitted as a radiation characteristic of the atom, and this, of course, in definite quantity. So much may be claimed as at any rate giving a first approximation to the truth. The results of experiments, however, suggest the possibility of the necessity for some modification of this theory in detail, though not in principle. For in the one case thoroughly investigated we get a nearer approximation to the experimental results by writing

(2) Total absorption per electron emitted $= \frac{1}{2}mv^2 + hn_K + hn_L$, where n_K and n_L are the frequencies of the K and L fluorescent radiations respectively. As the third term (hn_L) is at its maximum value only about 7 per cent. of the whole, it is impossible at this stage to say definitely whether or not it expresses a physical fact. This term was, however, suggested by a consideration of the probable process following the ejection of a K electron. The relation indicates that *possibly* the energy required to free a K electron is equal to the sum of the energies of quanta of K, L, and any other fluorescent radiation of lower series M, N, etc.—presumably originating in vibrations in the outer rings of the atom.

If we accept this provisionally it means that the energy of a quantum of K radiation is that required to displace a K electron into the position of an L electron, while the energy of a quantum of L radiation is that required to displace an L electron into the position of an M electron, and so on. Such a process may never occur; it is, however, a convenient way of expressing the energy required completely to eject the electron in terms of steps which can only be regarded as extremely probable in the inverse process involving radiation.

Thus the energy of a quantum of K radiation is left in the atom from which a K electron is hurled; or *possibly* the energies of one quantum of each of the fluorescent radiations, K, L, M, etc., are left in the atom. This energy must, of course, be radiated while the atom is regaining its original configuration by the absorption of an electron into the K position. It seems probable, however, that the readjustment of the atom and the principal radiation take place even before the atom as a whole regains an electron, by an L electron falling into the position of a displaced K electron, an M electron replacing an L electron, and so on; only the final stage of the readjustment being completed by the absorption of an electron into an outer depleted ring.

It is obvious in this case—unlike that studied by Bohr—when and why an electron falls into an inner ring; it is simply subsequent to and due to the removal of an inner ring electron. No new principle of radiation is involved, yet it accounts for radiation taking place in quanta. We should thus expect L radiation to be associated with the emission of K electrons as well as with L electrons. Search for such a radiation is at present being made. Pointing to the probability of such an associated radiation is the fact that when hn_L becomes a smaller fraction of the whole absorption, the discrepancy found when it is omitted, as in equation (1), diminishes. Not only is this so, but the energy of the corpuscular radiation and of the K fluorescent radiation actually emitted, do not quite fully account for the whole energy absorbed. The discovery of the L radiation in calculated intensity would give almost perfect agreement.

In spite of these indications the writer hesitates to make a definite statement about the physical reality of the third term concerned with L radiation; experiments will very soon decide the point.

In either case we have the direct evidence that the energy of a quantum is simply energy absorbed in removing the corresponding electron from its normal orbit; it is the energy afterwards set free, presumably when the electron returns.

It is hoped that experiments now being undertaken will determine also if X-ray fluorescence—that arising from the vibration of inner ring electrons—can be appreciably delayed by retarding the return of the ejected or other electrons from outside the atom. It is more probable that X-ray *phosphorescence* will not be detected, the readjustment of the interior of the atom taking place immediately after the ejection of an inner electron, and the final absorption of an electron into a surface ring being the only part of the process susceptible to external conditions. The subject can, however, only receive adequate treatment in communications to other journals. C. G. BARKLA.

University of Edinburgh, February 27.

The Physical Properties of Isotopes.

PROF. SODDY'S letter in NATURE of February 4 would seem to lead to certain interesting conclusions about the structure of the atom. It is easy to show that two elements of different atomic weight must differ either in their chemical or in their physical properties. If elements are inseparable chemically their affinity A must be equal. Now $A = -T\int_0^T \frac{U}{T^2}dT$ if T is the tem-

perature and $U=\int_0^T C_v dT$, where C_v is the atomic heat.

The fact that emerges most clearly from all the work done on this subject is that the atomic heats of similar substances may all be represented by the same function $f(\nu)$ of the atomic frequency ν. Therefore, if A is the same for isotopes, and this would seem to be the definition of the word, their atomic frequencies must be identical. But as ν is a function of the atomic weight and of the forces acting between the atoms, the latter must vary when the atomic weights are different. If the force of attraction between two atoms is $a\phi(r)$ and the repulsive force $b\psi(r)$, r being the distance, then at a sufficiently low temperature the quasi-elastic force holding an atom in position is $a=2k(a\phi'(r)-b\psi'(r))$. The constant k represents the action of the surrounding atoms and depends only upon the type of space-lattice formed by the atoms. As the atomic frequency $\nu=\frac{1}{2\pi}\sqrt{\frac{a}{M}}$ is the same for all isotopes, $\frac{a\phi'(r)-b\psi'(r)}{M}$ must be identical, whatever the atomic weight M may be. As Prof. Soddy has shown that the atomic volume and consequently r is also constant, it follows that both a and b must be proportional to the atomic weight.

This conclusion might, perhaps, be tested by a measurement of the vapour pressure of the different sorts of lead. The latent heat of sublimation λ is proportional to $a\int_r^\infty \phi(r)dr - b\int_r^\infty \psi(r)dr$, that is to M, as r is the same in both cases. The well-known equation $\lambda=RT^2\frac{d\ln p}{dT}$, where p is the vapour pressure, leads to $e^{\frac{\lambda_1-\lambda_2}{RT}}$ as the ratio of the vapour pressures, if the chemical constant is equal. This is of the order $e^{\frac{68}{T}}$ if M varies by 0·26 per cent, *i.e.* about 20 per cent. at 100° C. The vapour pressure of radium D the atomic weight of which is 210 should be about $e^{\frac{360}{T}}$ times less than that of ordinary lead, that is, 2·6 times less at 100° C.

Another posible test would be to measure the melting point. In a great many cases $\nu=\text{const.}\sqrt{\frac{T_m}{Mr^2}}$. As ν cannot vary, and as Prof. Soddy has shown that r is constant, the melting point T_m should be proportional to M. Thus, for instance, the melting point of Prof. Soddy's lead should be 1·54° higher than that of ordinary lead. In all probability the atomic weight of the final product of thorium is 208·4, in which case the difference in the melting point should be as much as 3·75°. These consequences are not necessary but, admitting the absolute chemical identity, highly probable. They include the assumption that the radii of the atoms are equal as well as their mean distance apart in the solid state. In any case, a measurement would seem well worth while, as a negative result would be of almost as great interest as if a difference were observed. Unfortunately, the elastic constants which should vary by a corresponding amount can scarcely be measured with sufficient accuracy.

The following conclusions about the structure of the atom would seem to result. The purely chemical properties are determined by the external electrons which probably also account for the apparent radius of the atom. The forces of attraction and repulsion between the atoms, the interaction of which results in the solid state, have their origin in the nucleus. In isotopes they are proportional to the atomic weight, *i.e.* probably to the number of positive particles. They cannot, however, be considered simply as the sum of the forces between the positive particles, as they are additive only in isotopes, that is, when the charge on the nucleus is equal. The simplest assumption, therefore, would appear to be that the nuclei of isotopes differ in their linear dimensions, but not at all, or only very little, in the arrangement of the particles.

F. A. LINDEMANN.

Sidholme, Sidmouth, February 10.

The Green Flash.

PROF. PORTER'S explanation of the green flash (NATURE, February 18) is unable to account for its appearance at sunrise, when it can be observed with great brilliance. When I was passing through the Indian Ocean on my way to observe the total eclipse of 1875 I happened to be on deck before sunrise one morning, and, watching for the first ray of the sun, was surprised to see the first flash of light appear as a vivid green. I had never heard of the phenomenon before, but atmospheric dispersion seemed to me sufficient to account for it, and I took it for granted that it was a well-known occurrence. I continued to observe the same effect several mornings in succession.

Since then I have undertaken many sea journeys, and though I do not recollect having ever again observed the flash or tried to observe it at sunrise, I have never lost an opportunity of watching for it at sunset. My experience does not support Prof. Porter's explanation, because the redder the sun at sunset, the less likely is the green flash to appear. The atmospheric conditions must be such that there is as little absorption as possible of the more refrangible part of the spectrum.

Those who want to see the appearance at its best should keep one eye closed as long as possible, and when the sun is just about to disappear, shut the eye which has been watching the setting sun, and open the other, which is then unaffected by the troublesome after-images which are otherwise seen. It is, of course, impossible to open the eye just at the critical moment, so that this alone is not sufficient to disprove Prof. Porter's explanation.

ARTHUR SCHUSTER.

Yeldall, Twyford, Berks., February 21.

Hormones and Heredity.

THE reviewer of Mr. H. Elliot's translation of Lamarck's "Philosophie Zoologique" in NATURE of February 11 remarks: "Unless we have misunderstood, a similar suggestion was made by Mr. J. T. Cunningham in 1908." The word "similar" refers to an alleged suggestion by Prof. MacBride that hormones may afford a clue to a possible *modus operandi* of the transmission of modifications. I should be glad to know when and where Prof. MacBride's suggestion was published, as I have not heard of it before. It would seem from the terms of this review that neither Mr. H. Elliot nor J. A. T. are fully acquainted with my paper on the heredity of secondary sexual characters in relation to hormones, published in the *Archiv für Entwicklungsmechanik* in 1908. The hormone theory of heredity is elaborated in considerable detail in my paper. I do not think it is possible to misunderstand it, and it is much more than a "suggestion."

J. T. CUNNINGHAM.

S.W. Polytechnic, Chelsea, February 15.

IT seemed to me that there was some historical interest in recalling Mr. Cunningham's paper of 1908.

As I was unable at the time to refresh my memory on the subject, I wrote guardedly, "Unless we have misunderstood." A fitter expression would have been, "If we remember aright." It is satisfactory to know that my recollection was substantially correct. To object to the theory being called a "suggestion" seems fastidious. As to Prof. MacBride's suggestion, Mr. Elliot's reference was to a proof of vol. i. of "A Treatise on Embryology." J. A. T.

THE NATURAL HISTORY BUILDING OF THE UNITED STATES NATIONAL MUSEUM.[1]

MR. RATHBUN has done well to publish a full technical account of this building, which claims "to be greatly in advance of all other museum buildings intended for a similar purpose." The three objects aimed at have been storage, usable exhibition space, and laboratory accommodation. The epithet "usable" is important, for in exhibition galleries dark corners and obtrusive architectural details are worse than useless. "Usable" also implies facility of accommodation to growing and changing needs. With this in view, the building has been planned as a great shell, with few permanent division walls; and, by giving exceptional width to the main mass, the floor area is large in proportion to the extent of outer wall. The plan, which covers nearly four acres, shows a large pavilion surmounted by a rotunda facing south, and from it three wings extending towards the east, west, and north; the latter are connected near their outer ends by two L-shaped ranges, completing the enclosure of two large uncovered courts.

The length of the southern façade, shown in perspective in our Fig. 1, is 561 ft.; the greatest north and south measurement, which is along the middle block, is about 364 ft.; each court is 128 ft. square. The wings have a width of 116 ft.; and the L-shaped ranges a width of 61 ft.

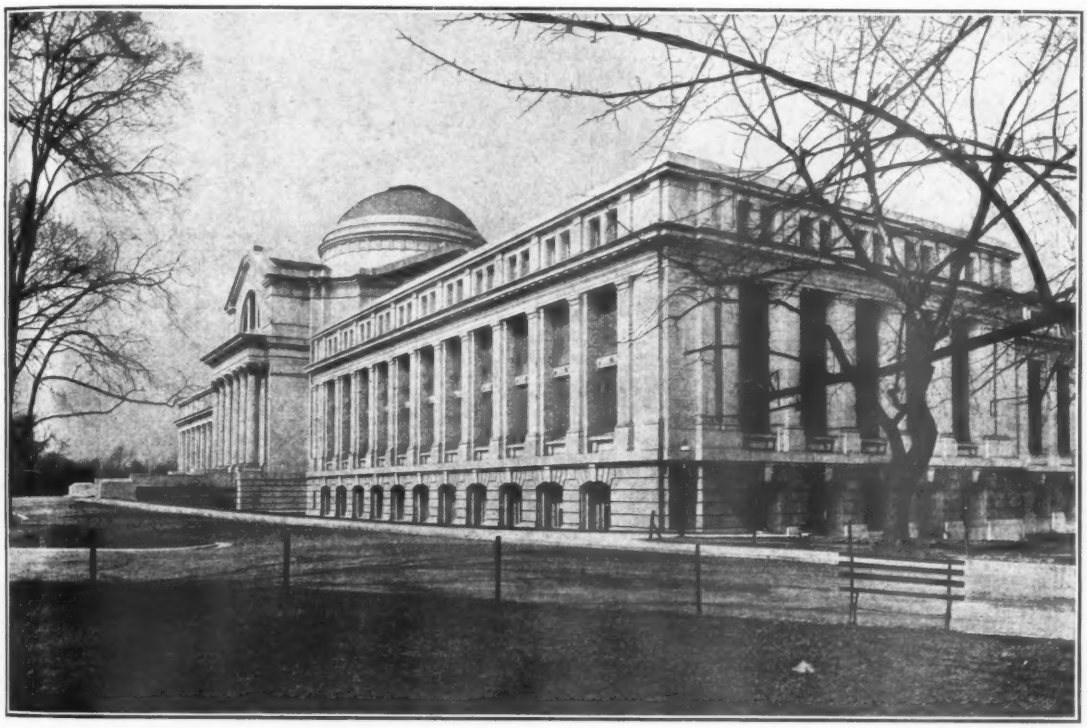

FIG. 1.—United States National Museum, Natural History Building, viewed from S.E., showing the South front, the outer end of the East wing, and the beginning of the East range.

This great width and the fact that the building is four storeys high might lead one to expect a deficiency of light. The modern classic style, however, has permitted exceptionally large windows (Fig. 1) in all but the upper storey, where, of course, skylights are available. Moreover, in these windows a maximum of glass surface has been secured by the use of light metal framing. Light is also furnished to the wings by light-wells 50 ft. wide, which break through the upper storeys and light all except the basement or ground storey. The floor of the first storey is thus all available, but the top-lit area is usually separated by glazed

[1] "A Descriptive Account of the Building recently Erected for the Departments of Natural History of the United States National Museum." By Richard Rathbun. U.S. National Museum, Bull. 80. Pp. 132+xxxiv plates. (Washington, 1913.)

screens from the surrounding aisles. Our second figure shows part of an L-shaped range on this floor, with the outer windows on the right, and on the left windows to the open court. The actual interior width is 54 ft. 2 in., and the ceiling height is 20 ft. The severity of the interior is not unpleasing, and for exhibition galleries is better than any ornament.

The general absence of interior structural walls has necessitated the introduction of piers and columns arranged in one or more rows, as shown on the right of our Fig. 2. These, as well as the wall piers, are at a distance of 18 ft. 6 in. from centre to centre. Rooms can be formed in multiples of this unit by the building of partitions between the columns, or to meet varying needs the exhibition galleries can likewise be broken up by slighter screens of material appropriate to each case. As the museum grows and changes there will be no difficulty in making such alterations, for all the mains from the heating and lighting plant run in tunnels under the basement, and are connected with each floor by two vertical chases cut in each wall pier. These chases also serve for electrical communications, ventilating flues, vacuum-cleaning pipes, hot and cold water supply, and the like. Thus for the future we can almost imagine that in this building "neither hammer, nor axe, nor any tool of iron" will be heard in the hands of the workmen, but that the staff will be left to work in peace.

The vacuum-cleaning pipes lead from a single pump in the basement, driven by a 25-h.p. motor, and are connected with seventy-three inlets to which can be attached rubber dust-hose provided with a complete equipment of dusting tools. These will be of particular value in the cleaning of exhibition cases.

The rounds of the night-watch are controlled by a system of recording clocks with paper dials, which mark the signals and transmit them to a central station. Time is indicated by sixteen dials electrically controlled by a master clock and corrected each noon from the Naval Observatory.

There are six electric Otis elevators, four for passengers and two for freight. The latter are near the large wagon entrances, and run from ground to attic; their cars measure 7 ft. 3 in. by 11 ft. 4 in., by 12 ft. high, and can take a load of 12,000 lb.

Nearly all the ground storey of the east wing is occupied by the machinery plant, which serves the older buildings also. Except for the generator engines, the two stoker engines, and six pumps in the engine-room, which are worked by steam, all motive power is supplied by electricity and is conveyed to the various laboratories and workshops.

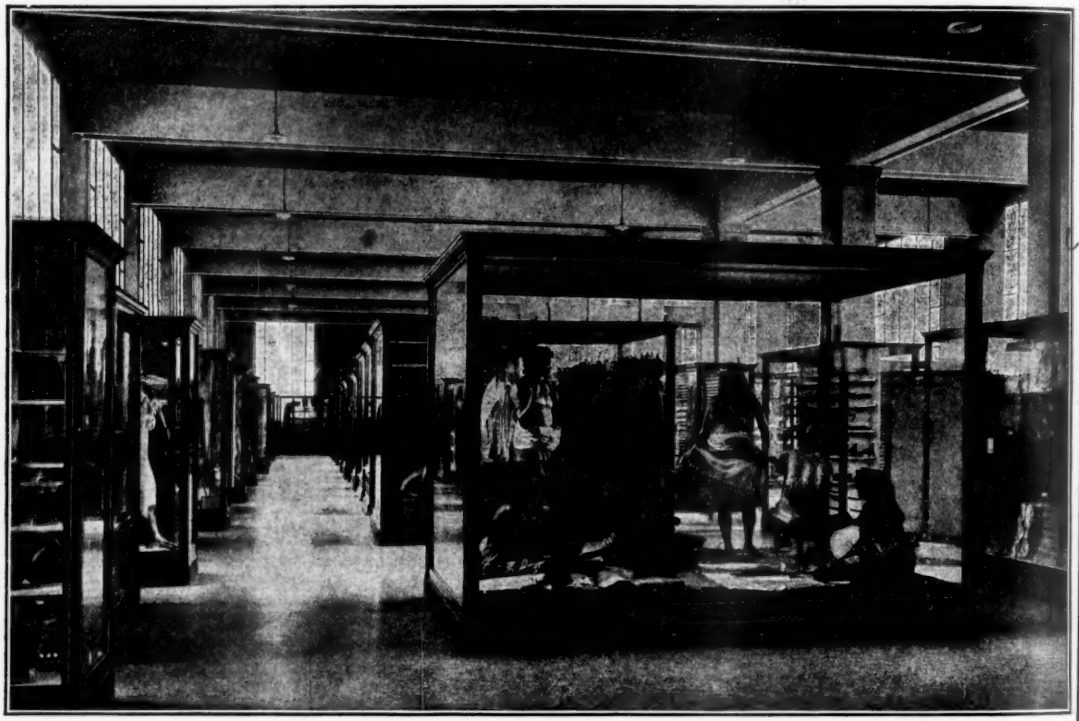

FIG. 2.—United States National Museum, Natural History Building. The Gallery of Ethnology, on the first storey of the East range.

The latter consist of painters', cabinet-makers', joiners', and metal-workers' shops, all on the south of this wing. This concentration warrants the use of machinery, and almost every kind of wood-working tool, down to the oil-stone, has its individual electric motor. The "sweat of man's brow" sounds archaic here, but none the less the artisans have a shower-bath and dressing-room. Each department has also its own laboratories, work-rooms, and "comfort-rooms."

The abundant storage space is fitted with standardised shelves, drawers, and cases, permitting ready rearrangement and interchange.

The auditorium is well designed, accessible, and isolated. There are also two rooms for committees and small scientific meetings.

This book does not profess to describe the installation of the exhibits, though a few plates (see Fig. 2) show the general effect. Its value lies in its account of structural detail and practical fitments; it should be read by every museum governor, and digested by every architect of future museum buildings. The claim advanced may not be substantiated at every point, but as regards those here mentioned it is enough to say that the United States Museum possesses what our own Natural History Museum notoriously lacks.

DUTY-FREE ALCOHOL FOR SCIENTIFIC PURPOSES.

IN the recent discussions on the best means of developing the colour industry in this country, reference has frequently been made to the duty charged upon pure methyl and ethyl alcohol, which are essential for certain products. Although the past and present stagnation is mainly due to other and much more deep-seated causes, the fact that the trade is still handicapped by a form of taxation which does not exist in Continental countries is one of the signs of the steady indifference of the Government to scientific industrial development of which Thomas Thomson so bitterly complained in his history of chemistry written nearly a century ago.

As the result of a very widespread feeling of dissatisfaction with the high cost of these alcohols (a feeling which had long existed in all the important centres of chemical research in this country) the subject was brought before the chemical section of the British Association at the Glasgow meeting in 1901, and an influential committee was formed, which was successful in persuading the Board of Inland Revenue to forgo the duty on methyl and ethyl alcohol used for scientific purposes in approved institutions. Their recommendations were embodied in the Finance Act of 1902, the working of which has, we believe, given general satisfaction. Whether or not the laboratories of manufacturing firms are permitted to share these advantages we cannot state. Yet in spite of the virtual, if tardy, concession of the principle that research can be usefully promoted in this way, one is constantly confronted with the sort of trivial annoyance such as Sir William Ramsay and Prof. Hickson have recently suffered at the hands of the excise authorities (see NATURE, February 11 and 18), who imposed a duty on the spirit in which specimens coming from abroad were preserved. "Red tape" seems almost too soft a material for binding the cast iron regulations which govern the Excise Department. If, however, the above principle is recognised and conceded, surely it might be adopted in a broad and, if possible, scientific spirit on the part of the authorities. It is not only carried out in the narrowest spirit of officialdom, but also is applied with an extraordinary absence of logic, such as is only conceivable where ignorance of the elements of organic chemistry exists.

For example, chloroform and ether made from ethyl alcohol pay duty, whereas that from methylated spirit (methylated ether) in one case and acetone in the other do not, although the products are practically identical. Again, methyl and ethyl alcohol used for research are exempt from duty, whereas ethyl acetate and butyrate, ethyl chloride, bromide, iodide, and chloral hydrate, in all of which ethyl alcohol is used, are not exempt. The corresponding methyl derivatives which are obtained in precisely the same way from methyl alcohol are not scheduled and, we presume, are free to all consumers. It may be seen from the table of excise regulations that chemists keeping or using stills are subject to a tax of ten shillings on each still, although it should be stated to the credit of the excise department that the payment is rarely if ever enforced in laboratories so far as we know. Perhaps at some future date the regulation may be modified. We see in all this a tardy and grudging response to those pressing demands for liberty of research, which foreign Governments have so successfully encouraged.

But it is not the duty on alcohol which has been the main factor in crippling the colour industry during the last thirty years. Nor is it defective training, equipment, or ability of the young chemists turned out from our universities, whose scientific work stands second to none. It is that the manufacturing world is only beginning to realise at this time of crisis in the chemical industry the true value of the research chemist. We say "beginning to realise," for it was only a few days ago that a professor of chemistry in one of our provincial universities received a request from a large and wealthy corporation to recommend a first-rate chemist, to whom the handsome salary of thirty shillings a week was offered, or about a third of the earnings of a coal-miner working full time!

It would take up too much space to attempt to trace the cause of that attitude of indifference among nearly all classes to the application of scientific research to industry which is such a striking feature of German commercial development. There can be no question that the key to the problem is to be found in our educational system. The very terms "humanities" and "stinks" are fraught with deep significance. They would appear to contrast what is real and living

with what is dead and corrupt; what is ennobling with what is contemptible. Yet if a comparison were possible it is the humanities which include the dead languages and literature and the history of dead institutions, whilst the sciences bring us directly into contact with present realities. Nevertheless, it is the former which take precedence in our public schools and our older seats of learning and command the highest marks in Civil Service examinations, whilst chemistry and the other sciences are tolerated though not encouraged, and are valued by the Civil Service commissioners at less than one-third that of the classics and one-quarter that of pure and applied mathematics.

The conclusions are obvious. Our highly-educated Government officials and princes of industry are more or less ignorant of science. It is for many of them an unknown and mysterious region into which they would prefer not to penetrate. That Nemesis now confronts our industries may be a blessing in disguise. It is only in a struggle that the weak points in one's armour are disclosed. We are learning a lesson, which might have been learnt years ago had we not been so inexorably bound by tradition, and the sooner we profit by it the better.

METEOROLOGY AND THE WAR.

IN an article which occupies a prominent position in *Le Petit Journal* of February 9, l'Abbé Moreux, the director of Bourges Observatory, emphasises the importance which Germany attaches to meteorological observations and forecasts in connection with the war on land, on sea, and in the air. The fact is scarcely surprising when it is remembered that the great damage done sixty years ago on November 14, 1854, to the allied fleets in the Black Sea by a storm, the course of which could be followed across Europe, was the factor which led Leverrier to conceive and inaugurate the service of international meteorological telegrams. Meteorology is essentially so co-operative and peaceful a science that its stormy birth is apt to be forgotten.

According to M. Moreux, Germany transferred meteorologists from Aix-la-Chapelle to Liège and then to Brussels almost simultaneously with the entry of her army into these cities; and when she found the Aix-la-Chapelle staff not sufficiently expert for her needs she brought up more competent authorities from Berlin and reinforced them with astronomers whose special duty was to watch sounding balloons. The evidence on this point does not appear, however, to be very conclusive, and from the marvellous successes in the prophetic sphere which have been attributed to the German representatives in Belgium it would appear probable that the race of Galeotti, and not that of Galileo, has been invited to render assistance.

Meteorology, along with other departments of science, is bound to have important bearings on the present war. It is, perhaps, more closely associated with the actual active operations than many other departments of science; but its application is not likely to be rendered more successful by substituting for men who are intimately acquainted with the subject men who have achieved distinction in quite a different field; nor by moving the experts from the central institution to the local field of operations. Progress in forecasting in recent years has been achieved by extending the area from which observations are received by telegraph rather than by special observations at a single place; and the meteorological expert's work is to co-ordinate the results of other people's observations, mainly by charting them, rather than to make the observations or to apply the deductions based upon them.

It may be added that in normal times Hamburg is the official centre of the German system of weather-telegraphy and forecasting.

NOTES.

WE announce with much regret the death on Monday, March 1, at seventy-five years of age, of Prof. James Geikie, F.R.S., emeritus professor of geology and mineralogy in the University of Edinburgh.

THE King of the Belgians, and Admiral Lord Fisher of Kilverstone, First Sea Lord of the Admiralty, have been elected honorary members of the Institution of Civil Engineers.

A BRONZE statue of Captain R. F. Scott, erected at Portsmouth Dockyard by the subscriptions of naval officers and officials of the Dockyard, was unveiled on February 26 by Admiral Sir Hedworth Meux, the Commander-in-Chief at Portsmouth. The monument is the work of Lady Scott, and shows Captain Scott in his Antarctic dress.

THE following candidates have been selected by the Council of the Royal Society to be recommended for election into the Society:—Prof. F. W. Andrewes, Prof. A. W. Conway, Mr. L. Doncaster, Mr. J. Evershed, Dr. W. M. Fletcher, Prof. A. G. Green, Mr. H. H. Hayden, Dr. J. Mackenzie, Prof. J. C. McLennan, Dr. A. T. Masterman, Prof. G. T. Morgan, Dr. C. S. Myers, Mr. G. C. Simpson, Mr. A. A. Campbell Swinton, Mr. A. G. Tansley.

WE regret to see the announcement of the death, in his fifty-seventh year, of Mr. Frank T. Bullen, whose knowledge of the sea and its natural history made him distinguished among writers of sea stories. Mr. Bullen was a junior clerk in the Meteorological Office for several years previous to 1899, and while occupying that post he contributed to NATURE of June 4, 1896, a very interesting article on "The Sperm Whale and its Food." This was before he had attained fame by his book, "The Cruise of the Cachalot," but we were impressed at the time by the clear and attractive style of the article, and were glad to know that later Mr. Bullen's real literary gifts received general recognition.

SIR CHARLES A. PARSONS has made a gift of 5000*l.* to the Royal Institution. The following resolution

passed by the managers was approved by the members on March 1:—"That the managers of the Royal Institution desire to express to the Hon. Sir Charles A. Parsons, K.C.B., F.R.S.,, who has unconditionally placed at their disposal, for the purposes of the institution, the sum of 5000*l.*, their most grateful appreciation of his munificence and discernment. They accept the gift as a timely and noble recognition of the good public work the institution has done in the past, and is still doing, in the acquisition and diffusion of scientific knowledge, and as an incitement to maintain and extend its usefulness in the unique position which it has for more than a century occupied."

NEWS received from the Russian Arctic voyager Vilkitski now definitely locates him in Taimyr Bay, to the west of Cape Chelyuskin. A wireless message from him has been picked up by Captain Sverdrup, who is laid up further to the south-west on the same inhospitable coast. Vilkitski, having set out in July from Vladivostok to make the passage to European Russia, has thus accomplished about three-fifths of the voyage along the Russian arctic coast. He proposes to send some of his men to Sverdrup, thus relieving the pressure upon his supplies, for he has encountered such heavy ice conditions hitherto that it does not seem certain that he will be able to get on with his ships next summer. The expedition has ample opportunity to add to geographical knowledge (as it has done already) on the coast where it is now imprisoned.

THE appeal for subscriptions to the Sir William White Memorial Fund has resulted in a sum of 3076*l.* 14*s.* 6*d.*, contributed by 455 subscribers. The committee of the fund has decided that the most suitable form which the memorial could take would be the establishment of a research scholarship in naval architecture to be named after Sir William White; and it has been arranged to hand over to the council of the Institution of Naval Architects the greater part of the funds subscribed so that a sum of at least 100*l.* a year shall be available for the scholarship, which will be administered by the council of that institution. In addition, a medallion portrait will be placed in the new building of the Institution of Civil Engineers; and, finally, at the suggestion of Lady White, a donation of one hundred guineas has been made to the Westminster Hospital, where Sir William White passed away.

A REVISED memorandum on cerebro-spinal meningitis, or "spotted fever," has been issued by the Local Government Board in view of cases of the disease which have occurred in various part of the country. It is issued as a purely precautionary measure, and is intended to indicate to medical practitioners, especially village doctors, that the department is watching the outbreak, and that should suspicious cases occur, free bacteriological examination and isolation accommodation will at once be provided. Suspicious cases should be isolated immediately, and any contact cases closely watched. A warning is issued against overcrowding, and as the germs are first located at the back of the throat any person even slightly suspected of having contracted the disease should refrain from kissing anyone else. So far as the general public is concerned, the outbreak may be regarded with indifference. In London it is stated that not more than twenty cases of the disease have been recognised during the last two months.

WE have recorded already the sudden death, on February 13, of Prof. Wesley Mills, emeritus professor of physiology, McGill University, Montreal. From an obituary notice in the issue of the *British Medical Journal* of February 27 we learn that Prof. Mills took the degree of M.D. in McGill University in 1878. He was for several years demonstrator of physiology with Sir William Osler, and studied at University College with Sir J. Burden-Sanderson and Sir E. A. Schäfer. In 1884 he became lecturer in physiology, and in 1886 professor of the subject at McGill University. He organised the teaching of physiology on modern lines, and was the first Canadian teacher of the subject to have a thoroughly up-to-date, well-equipped laboratory. Among his early contributions to physiology were the studies of cardiac innervation. He became much interested in comparative physiology, and the results of a long series of studies are embodied in a work on "The Nature and Development of Animal Intelligence." In 1889 appeared his "Text-book of Animal Physiology," which was modified in the new edition of 1890 to the "Text-book of Comparative Physiology." In 1906 appeared his "Voice Production in Singing and Speaking," a work which brought him much reputation outside of medical circles. After a serious illness in 1910 he retired, and lived in London, devoting himself with energy and enthusiasm to the study of music.

THE Royal Swedish Academy of Science, Stockholm, has recently erected a monument in the Swedish cemetery at Brookwood, Woking, to the memory of Daniel Solander, F.R.S. The memorial consists of an obelisk of unhewn Swedish stone, with the inscription of the name, and dates of birth and death, and that the memorial was erected by the Academy. Daniel Solander was the son of a clergyman in Pite Lappmark, was born in 1733, entered the University of Uppsala as a student in 1750, and left his native country ten years later for London. Here he became employed in the British Museum, in 1764 was elected a Fellow of the Royal Society, and in 1767 made the acquaintance of Banks, who induced Solander to travel with him in that eventful voyage in the *Endeavour* which was Cook's first expedition to the southern seas. On returning from this voyage in 1771, Solander was adopted by Banks as his secretary and librarian, until his death in 1782 from an apoplectic seizure, in the presence of Sir Charles Blagden and the younger Linnæus, dying ten days later. There exist several portraits of Solander; one, a full-length engraving depicting him as "a Simpling Salamander," another of head and bust to left; and, by far the best, a full-length portrait in oil, by John Zoffany, which belongs to the Linnean Society, and was copied for Sir Joseph Hooker's edition of Banks's *Journal*, published in 1896.

THE death is announced, on February 20, of Dr. Ed. C. Seaton, consulting medical officer of health to the Surrey County Council. We are indebted to the *British Medical Journal* for the following particulars of his life and work. He studied medicine at St. Thomas's Hospital, and took the degree of M.D. at the University of London in 1871. From 1886 to 1908 he was lecturer on public health at St. Thomas's Hospital, and was at different times examiner in State medicine in the Universities of London, Oxford, and Cambridge, and at the Royal Colleges of Physicians and Surgeons of London. He was the author of the article on vaccination in Quain's "Dictionary of Medicine." He delivered the address in public medicine at the annual meeting of the British Medical Association in 1891, taking as his subject the evolution of sanitary administration in England. He read a communication on diphtheria before the International Congress of Medicine at Budapest in 1894, and delivered the Milroy Lectures at the Royal College of Physicians in 1896. His Chadwick Lectures at the University of London on "Infectious Diseases and their Preventive Treatment," published in 1910, may be taken as containing a summary of his matured views on subjects to the study of which he had given his professional life. Dr. Seaton took an active part in promoting legislation for the compulsory notification of infectious diseases, and was the author of numerous reports and papers on the subject. He was a Fellow of the Royal Sanitary Institute and a member of the Society of Public Analysts. For more than forty years he was a member of the British Medical Association.

SHORTLY after the commencement of the war, the British Science Guild referred to two of its committees the question of the supply of laboratory and optical glasses, most of which had been obtained from Germany and Austria. The reports of these committees have now been completed, and will be issued shortly. The Institute of Chemistry took up the subject about the same time, and appointed a Glass Research Committee, the main purpose of which was to determine, by experiment, the constitution of glasses suitable for various purposes and to communicate the formulæ to manufacturers. The research has been carried on at King's College, London, and formulæ have been arrived at for an alumina-soda glass suitable for the manufacture of chemical laboratory ware and for a glass which is a satisfactory substitute for Jena glass in respect of its resistance to water and reagents. Provided with these and other formulæ, the only question left for manufacturers contemplating the laying down of plant for the production of laboratory glass to consider was the prospect of the industry after the war. In order to obtain information upon this point, the British Science Guild, acting jointly with the Association of Public School Science Masters, sent a circular letter to local education committees throughout England, councils of universities and technical institutions, and governors of the chief secondary schools, including all the public schools represented on the Headmasters' Conference. The result of the inquiry has been most satisfactory. In general it may be said that about three-quarters of the bodies concerned have undertaken to use British-made laboratory glass during the war, and for a period of three years after, provided that the price is not prohibitive. Two scientific organisations, on their own initiative and without any assistance, financial or otherwise, from the Government, have thus been able to do most valuable work for British glass manufacture. It is to be hoped that official recognition will be given to the service they have rendered to national welfare.

THE question of the origin of culture, through direct transmission by migration or trade from a single centre, or by independent evolution in more than one area, is in the air at present. A useful contribution to the controversy is provided by Mr. Eldson Best in the January issue of *Man*. One of the most beautiful of the several types of greenstone pendants made by the Neolithic Maori is that called the Tautau. The existence of this type has been, at various times, advanced as proof of American and Asiatic relationships in Maori art, and Mr. Hamilton, the best authority on the subject, states that this form is as yet unexplained. Mr. Best now brings forward evidence to show that this type is indigenous and not genetically related to objects of similar shape found in other parts of the world. He traces its origin to a form of fish-hook consisting of a bone barb, sometimes beautifully carved, fitted into a hole which passes through the lower end of a straight wooden shaft. A series of illustrations indicates the phases through which the ornament was gradually developed from this form of fish-hook.

MR. A. S. F. GOW contributes to the *Journal of Hellenic Studies*, vol. xxxiv., part 2, a valuable paper on the evolution of the plough of Greek and Roman days. It starts with those ploughs in which the main timbers are of one piece. Then follows the plough which has stock and pole in one piece, but the tail inserted artificially. The next step in complexity is when all the three main members are separate timbers artificially joined. Fourthly, comes the variety in which pole and tail rise together from the hinder part of the stock, stock and pole have lost the exaggerated solidity seen in the earlier examples, and the pole, not the stock, is now the most important member in the implement. The accounts of the plough in Virgil and Hesiod are carefully discussed, with other classical references, and the paper is illustrated with a good series of photographs from the monuments and of modern Greek and Italian ploughs. The writer does not seem to be acquainted with the important article by Sir E. Tylor, "On the Origin of the Plough and Wheel-Carriage," in vol. x. of the Journal of the Anthropological Institute (1881).

WE have received from Mr. E. J. Brill, of Leyden, a catalogue of books and pamphlets dealing with the geology, botany, zoology, etc., of the Dutch East Indies, together with others relating to tropical diseases and medicine and climatology.

AT the monthly general meeting of the Zoological Society, held on February 17, it was stated in the

report of the council that thirty additions had been made to the menagerie during January, of which twenty-two were acquired by presentation, one by purchase, and two by exchange, while three were received on deposit, and two were born in the gardens. Amongst these was a sing-sing waterbuck, a squirrel-monkey, a kinkajou, two Senegal genets, and a spotted firefinch (*Lagonosticta niveiguttata*), the last a species new to the collection.

IN the reports on the Hunterian Collections in the University of Glasgow for 1913–14 it is stated that, in addition to a considerable number previously identified, many type-specimens of insects described by Fabricius have been recognised recently, as well as a number of the specimens figured in Drury's "Illustrations of Natural History," and Olivier's "Entomologie," 1789–1808. These the curator hopes may eventually be housed in a fireproof building. All the collections are reported to be in good condition; and in some instances have received considerable augmentation during the period under review.

NEXT time the editor of *My Children's Magazine* requires a picture of a whale he would be well advised to send his artist to the Natural History Museum instead of allowing him to evolve from his own mind the grotesque caricature of a sperm-whale (with upper teeth!) which forms the frontispiece to the March issue of that journal. The picture is intended to represent a whale stranded at Greenwich in the time of John Evelyn, by whom it was seen and measured. There is no proof that this was a sperm-whale, and it was much more probably a common rorqual (as is suggested by Evelyn's mention of a "picked snout"), a species of which, a female, was stranded some twenty years ago at Woolwich, where it gave birth to a couple of young. Another error in the same issue is the statement that the wool used in the manufacture of "cashmere" is the product of *wild* goats.

MR. C. F. JURITZ contributes a paper on plant poisons of South African plants in vol. xi., No. 4, of the *South African Journal of Science*, which is of value in pointing out the pharmacological possibilities of the rich native flora. Interesting particulars are given of the toxic properties of the fruits of the Cycad, Encephalartos, various Liliaceæ, and Amaryllidaceæ, which are so numerous at the Cape, and of many other plants under their respective natural orders.

THE pocket-book for 1915 issued by the Royal Botanic Society of London is a mine of miscellaneous and very useful information, giving not only the various horticultural fixtures for the year, but also such things as the different weights and measures and their conversion from one system to another, physical constants, chemical constituents of gems, the composition of soils, manures and their uses for different kinds of trees and plants, and so on. Several pages are devoted to lists of economic plants with their botanical names, natural orders, and uses, which form a very handy source of reference. At the end there is a plan of a tennis-court and croquet-lawn, but the Badminton court, which might have found a place, is not included.

JAPANESE primulas form the subject of an illustrated article by Mr. Takeda in No. xxxviii., vol. viii., of Notes from the Royal Botanic Garden, Edinburgh. Though China is the home *par excellence* of the genus, Japan, according to the present paper, possesses eleven native species. Of these *P. Sieboldii* and *P. japonica* are the best known. Hybridisation, which is uncommon, as a rule, in the genus, is common among the Japanese species, and *P. Sieboldii* is conspicuous as a parent of many hybrids. In the same number of the Notes fifty new Chinese plants are described, collected by G. Forrest or F. K. Ward in West China at altitudes of from 12,000 to 16,000 ft. *Draba alpina*, var. *involucrata*, from the Lichiang range at 15,000 to 16,000 ft., has been grown at the Edinburgh Botanic Garden. Other high-altitude plants are the gentians and saxifrages collected by F. K. Ward on the borders of Yunnan and Tibet up to 16,000 ft.

THE Hawaiian Volcano Research Association is a society founded in 1909 and supported by voluntary contributions. Its objects are to record volcanic outbursts and earthquakes in the Hawaiian Islands, and to offer opportunities to scientific men to pursue special studies in connection with volcanic action. The association possesses a volcano observatory near the edge of the crater of Kilauea, and a seismological station at a short distance which is furnished with two Bosch-Omori tromometers, an Omori tromometer, and an Omori seismograph. Weekly bulletins are issued in which the continual changes within the craters are described and lists are given of the numerous earthquakes recorded. An appeal for funds has recently been issued by the board of directors, partly for scientific objects, partly for the construction of stone refuge houses along the north-east rift line of Mauna Loa, as it is almost certain that an outflow of lava will shortly take place along that line.

ATTENTION has been directed on more than one occasion in these columns to the need of journals publishing summaries of current mathematical work in the form of lists of new books and of the contents of periodicals. This has been a feature of the Bulletin of the Calcutta Mathematical Society, which, however, has up till now reached us considerably out of date. The Tôhoku Mathematical Journal (vol. vi.), published in Sendai, Japan, now publishes these lists, and although some of the printed matter is scarcely likely to be intelligible to the majority of English readers, the titles of many papers are at any rate printed in the language of publication, and the references are to recent work.

IN his "Notes on Some Focometric Apparatus" in the December, 1914, number of the Journal of the Royal Microscopical Society, Mr. F. J. Cheshire states that he has found the following modification of Blakesley's arrangement for determining the focal length of a short-focus system by the method of magnification, most convenient for the ordinary requirements of the microscopist. An achromatic system of focal length 2·6 cm. is mounted in the middle of a tube having a millimetre scale at its lower and a slit

a millimetre wide at its upper end, the slit and scale being at the foci of the system. The tube is fitted under the stage of a microscope with the slit in the plane of the stage. The eyepiece of the microscope is provided with a graduated scale, and on focussing the lower scale, the number of eyepiece divisions corresponding to a lower scale divisions is read. The system the focal length of which is to be determined is then introduced between the objective and the slit, the microscope again focussed, and the number of eyepiece divisions covered by a division of the lower scale again read. The quotient of the two readings gives the focal length of the system. By a proper choice of scales the focal length may obviously be read at one operation in any desired unit.

THE Bureau of Standards, Washington, U.S.A., has issued a circular (No. 51) describing the method adopted for testing watches and timepieces, and detailing the conditions under which the bureau is prepared to issue certificates showing the quality of the performance. The tests naturally do not differ greatly from those that experience has proved to be practical and satisfactory in other observatories and institutions, where regular tests are carried on. An omission of some importance, as it seems to us, is the failure to mention the connection between this testing department and any observatory of repute. No information is provided as to the manner in which the time determinations are made, or how the errors of the mean time clock are eliminated. The bureau may be in connection with the U.S. Naval Observatory at Washington, and the authorities in charge of that observatory may be responsible for the accuracy of the time record. More distinctness on this head would have been welcome, as in the last report from the Naval Observatory it was stated that an insufficient number of chronometers and watches were submitted for trial, and that every effort was being made to induce makers to submit instruments for test. Some useful information is provided concerning the care and treatment of accurate timekeepers, and a table is given showing the main centres on railways, etc., where the change of time is made in passing critical meridians. Where so many abrupt changes occur between the Atlantic and Pacific coasts, this table should prove valuable.

IN No. 1, vol. iv., of the Memoirs of the Department of Agriculture in India, Harrison and Subramania continue the account of their work on the gases of swamp rice soils. In the first paper on this subject it was suggested that the gases formed in the soil had an important connection with the aeration of the roots of the crop. This theory is now elaborated, and a detailed investigation is made of the mechanism by which the organised film, in contact with the surface of these swamp soils, utilises the soil gases for the production of oxygen. It is shown by experiment that the film can oxidise both methane and hydrogen, and, further, that the resulting carbon dioxide is decomposed, with evolution of oxygen, by the green algæ and diatoms which are always present in the film. Crude cultures of bacteria have been prepared capable of bringing about the first of these changes, but no specific organism was isolated having the power to oxidise either methane or hydrogen in pure culture. A mixed culture of two organisms, however, is stated to oxidise hydrogen to water in the presence of very small amounts of nitrogenous organic matter. The film may be looked upon as fulfilling the duty of an oxygen concentrator at a point which enables the maximum oxygen concentration to be produced in the water entering the soil. The practice of green manuring increases the production of soil gases, which is otherwise comparatively small, leading to an increased oxygen output by the surface film and better root aeration. Hence there is deeper root development resulting in sturdier and more productive plants. A further paper dealing mainly with the bacteriological side of the investigation is to be published shortly.

THE Isthmian Canal Commissioners decided some time ago that the requirements of the Panama Canal necessitated the provision of two large floating cranes capable of handling such heavy loads as the largest lock- and dock-gate leaves. Tenders were asked for two floating cranes, each of 250 tons capacity, and the contract was awarded to the Deutsche Maschinen Fabrik A.-G., of Duisburg, because "the proposal of the German firm was so much lower in price than any other, and the experience, facilities, and reputation of this firm so excellent, that it was unquestionably the best of those received." The quotation is from the official records, and *Engineering* for February 26 aptly puts the question as to whether this opinion is still held in view of what happened to the first of the cranes when undergoing its test loading. The load was not quite out to the specified distance when the jib collapsed. Our contemporary publishes photographs of the crane after the accident, from which it appears that the jib was insufficiently braced, and that the accident might have been avoided by the presence of a few additional members. The damage is estimated at about 120,000 dollars, and the work will take about six months to put right.

THE *Engineer* for February 26 gives an illustrated description of an enormous locomotive built for the Erie Railroad by the Baldwin Locomotive Works of Philadelphia. The engine is of the 2-8-8-8-2 type in wheel arrangement, and has six cylinders; two of the cylinders are high-pressure, and each of these exhausts into two low-pressure cylinders. All the cylinders are of the same size, viz., 36 in. diameter and 32 in. stroke. The wheel base is 90 ft. in length, and 89 per cent. of the weight of the engine and tender is carried on the driving wheels. The boiler is 8 ft. diameter at the smoke-box and 9 ft. diameter at the dome. A Schmidt superheater having 1584 sq. ft. of surface is fitted, and is said to be the largest yet made for a locomotive. The total weight of the engine and tender is 380 tons (long). The engine will do duty as a banking engine on a long gradient of 1 in 95, where at present the standard goods train, hauled by a 2-8-0 engine, requires two 2-8-0 engines and a Mallet engine as combined banking engines. The new engine will do the work of the three present engines on the bank. It will be coupled into the middle of the train, thus reducing the stresses on the couplings and drawbars

and avoiding any tendency to buckle the train in the middle due to excessive pushing forces in the rear.

THE forthcoming books of Messrs. John Wiley and Sons, Inc. (New York), include:—Elementary Chemical Microscopy, E. M. Chamot; The Examination of Hydrocarbon Oils and of Saponifiable Fats, D. Holde, translated by E. Mueller; Text-Book of Geology, L. V. Pirsson and C. Schuchert; A Meteorological Treatise on the Circulation and Radiation in the Atmospheres of the Earth and of the Sun, F. H. Bigelow; Manual for Health Officers, J. S. MacNutt; Constant-Voltage Transmission, H. B. Dwight; Field Book of Railroad Engineering, W. G. Raymond; Materials of Construction: their Manufacture, Properties and Uses, A. P. Mills; Steam Power, C. F. Hirshfeld and T. C. Ulbricht; The Railroad Taper: the Theory and Application of a Compound Transition Curve based upon 30-foot Chords, L. Perkins; Working Data for Irrigation Engineers, E. A. Moritz; A Shop Mathematics for Machinists, R. W. Burnham; Interpolated Six-Place Tables, H. W. Marsh; Masonry, M. A. Howe; Plain and Reinforced Concrete Arches, J. Melan, translated by D. B. Steinman.

OUR ASTRONOMICAL COLUMN.

THE RETURN OF METCALF'S COMET?—In NATURE of February 25 reference was made to a telegram received by Prof. Strömgren relative to the discovery of an object by Miss Leavitt believed to be Metcalf's comet. The *Morning Post* of February 23 published the following paragraph relative to this discovery: "A telegram from Prof. Pickering has just been received stating that the object reported as Comet Metcalf turns out to be a minor planet. This must be a disappointment to Miss Leavitt, but it accounts for the failure of astronomers to find the comet when better placed. The question of priority of discovery, as evidenced by the Southern comet of last year, which was discovered independently at Johannesburg, Arequipa, and Christchurch, New Zealand, on the very same day, has been already responsible for premature publication. Prof. Pickering is, however, generally prepared to take the risk and is sometimes fully justified."

THE CANADIAN 72-INCH REFLECTING TELESCOPE.—Dr. J. S. Plaskett communicates some very satisfactory information about the large Canadian mirror which is in process of being worked up. (Journal of the Royal Astronomical Society of Canada, Nov.–Dec., 1914.) The mirror is actually 73⅝ inches in diameter and 13⅝ inches thick, weighing 4962 pounds, or a little more than two tons. An excellent idea of the size of this vast piece of glass will be gathered from the illustration accompanying Dr. Plaskett's note, showing the disc with Dr. John Brashear sitting beside it. Already the edge has been ground, the labour occupying three weeks, and the more delicate and dangerous work of drilling the central hole has been satisfactorily completed. The latter involved first boring a hole of 9 inches diameter, then enlarging it to 10 inches, and finally smoothing and squaring it up and bevelling off the top edge. The next procedure is the figuring of the upper and lower surfaces to make each plane in order to choose which surface is the more suitable for shaping into parabolic form. It is satisfactory to read that "the more the disc is examined the better it seems to be, and hopes are high that it will prove a great success."

ANOMALOUS DISPERSION IN THE SUN.—No. 93 of the Contributions from the Mount Wilson Observatory contains a communication from Mr. Charles E. St. John, entitled "Anomalous Dispersion in the Sun in the Light of Observations." Mr. St. John first directs attention to recent publications by Prof. Julius, who has considered the displacements of the Fraunhofer lines at the centre and limb edges of eccentrically located sun-spots from the point of view of his theory of anomalous dispersion. In these Prof. Julius has set forth "a new deduction from the theory of anomalous dispersion—the "mutual influence" of the Fraunhofer lines upon each other; in particular, that a weak line on the violet side of, and near to, a stronger line is displaced less, but if on the red side more, than the average amount." The above deduction affords Mr. St. John, as he says, an opportunity of making a quantitative test of the rôle played by anomalous dispersion in the solar atmosphere, and this he does in the present paper. It may be remarked that Prof. Julius used the data published by Mr. St. John in his paper, "Radial Motion in Sun-spots." In the present discussion, which covers more than forty pages, it is impossible to refer even briefly to any of the details here stated. Mr. St. John sums up in eleven paragraphs the results of his investigation, and the reader must refer to the article itself for further information. The general result may, however, be expressed by reproducing the last paragraph of the summary. "The general conclusion from this review of solar observations is that the deductions from the anomalous dispersion theory which are susceptible of definite and quantitative tests are not supported by the observational data, and that observations are outstanding which have not yet been explained by the theory."

GREAT DETONATING FIREBALL IN SOUTH AFRICA.—Some of the South African newspapers just received give particulars of a fireball which appeared nearly over Cradock and Queenstown on January 9 last at 1.20 a.m. It vividly illuminated the heavens for several seconds, and was followed shortly after by a series of loud explosions.

The meteor evidently came from the N.N.W., passing between Cradock and Queenstown, and finally disappearing to the S.E. of the former place at a distance of about 24 miles, but the exact figures are doubtful. The estimated interval between the flash and the detonation was variously given by different persons at Cradock between 30 seconds and 3 minutes. The meteor may have fallen to the earth in the region S.E. of Cradock, and it is to be hoped that a thorough search has been instituted for the object. Its flight appears to have been directed from the position of the radiant of the January meteoric shower from Quadrans, the maximum display from which is usually developed on January 3. But the shower is certainly prolonged until January 9. The meteor, however, more probably owed its origin to a radiant in the constellation Draco.

The recent meteor startled a large number of persons by its loud detonation. Houses are said to have been shaken, and the visitation was ascribed by many people to an earthquake. The real path cannot be satisfactorily computed from the observations, which are not of a suitably exact character. The period from January 9 to 14 is notably rich in fireballs, and it merits further investigation. There are evidently a number of radiant points active at this epoch, and among those best pronounced will be found positions at $120°+0°$, $148°-12°$, $230°+52°$, and $332°+36°$.

PROFESSIONAL CHEMISTS AND THE WAR.[1]

IT is a matter of importance to the representatives of the chemical profession that their aspect of the great coal-tar colour industry should be kept well to the fore in the Government scheme and in any other scheme that may hereafter be put forward. We desire to see the restoration of the industry to this country, and not only restored, but also permanently retained after the war. The discussions of the Government schemes in various parts of the country by dye-consuming organisations, chambers of commerce, and so forth, have all centred round political or economic questions; the vital principle, viz., adequate chemical control, has been subordinated or left out of consideration altogether. While there has been much wrangling over the question as to the method by which the industry may be established and maintained here, whether by free trade or protection, or subvention, or by any other device, the consideration of the questions whether a few years hence there will be anything in the way of dyestuffs worth protecting; whether there will be a sufficient basis of material products left for the politicians and economists and business people to wrangle over has been overlooked. It is not a purely business problem which the Government has undertaken to solve; it is primarily a chemical problem.

The conditions which have to be met if this country is to be once more the home of the colour industry are imperfectly understood by the public. Even those most concerned—those who are invited to subscribe to the capital—appear in most cases to have an idea that all that is necessary is to find the money, secure Government aid, appoint a board of business directors, and lo! the industry will forthwith spring into existence ready to cope with all emergencies. What are the facts of the case? About five hundred different dyestuffs of definite composition have been given to tinctorial industry as the products of chemical research. Of these a certain number only can be, and are being, made in this country. The total output of our factories is, at present, inadequate for the requirements of our textile industries. The first step to be taken, therefore, is to enlarge and develop existing factories so that the dyes which can be made here may be turned out in larger quantities. This necessity has been provided for in the Government scheme, and "so far so good." If the extension of the existing factories still produces insufficient supplies, new factories must be erected and equipped. That also is provided for in the scheme; but if we want to establish the industry here permanently we must look beyond all this. Where shall we be left after the war? We shall be in possession of processes for making a certain number of dyes, and the supply of their products may possibly be sufficient for the particular purposes for which they are required. But there will still be an outstanding number of other products which have never yet been made here, and for the working out of these processes no combination of "business" talent is of the slightest value. It is not a business question, but a chemical question, and it is by chemical research alone that our colour industry will be saved. The German colour industry has been built up by the utilisation of the results of research carried on in the factories and universities and technical schools for a period of more than forty years! To suppose that we can retrieve our position by starting a company the directorate of which was to consist solely of business people is ludicrous.

One feature of the new scheme which the chemical profession can view with favour is the distinct recognition of research as a necessity for the development of the industry. The Government "will, for ten years, grant not more than 100,000*l.* for experimental and laboratory work." That is certainly a concession which marks an advance in official opinion. It will be for the satirist of the future to point out that it required a European war of unparalleled magnitude to bring about this official recognition of the bearing of science upon industry. Who is to direct this research? A directorate of purely business people will certainly be incompetent; a board composed of dye users can do no more than indicate what dyestuffs were needed. True, it is proposed that the company should take powers to secure the assistance of a committee of experts, but this appears to be simply a reversion to the policy of "drift." The experts are, as usual in this country, to be subordinated and their assistance is to be invoked at the discretion of a board the members of which can have no real knowledge of the conditions necessary for producing the materials they require. Will they be competent to point out dangers ahead? The "staple products" upon which they are asked to stake their capital may a few years hence be superseded by the products of later discovery. The policy of attempting to run a highly specialised and rapidly developing branch of organic chemical industry by a company of business people with expert assistance when required is fatal if it is intended to establish the industry permanently here. The group of industries which has arisen from the products of the tar still is not going to remain stagnant after the war, and it is scientific guidance and not mere assistance that will keep them alive. It is the expert, and the expert only, who can foresee the course of development, who can keep in touch with the progress of research, and direct with intelligence the campaign against competitors. If such scientific direction is withheld, all schemes are sooner or later bound to end in failure.

To other branches of manufacture in which our dependence upon foreign products has been forcibly revealed by the war, professional chemists have been able to render considerable service. It has long been known that laboratory glass and porcelain apparatus and filter paper have been mainly supplied from abroad, and that large quantities of pure chemical reagents and of the special chemicals required for analytical or research work have borne non-British labels. This state of affairs called for prompt action, and the councils of the Institute of Chemistry and the Society of Public Analysts have acted conjointly as a committee for dealing with this matter of such vital importance to the profession. The inquiries instituted by this committee soon brought the fact that failure in the supply of laboratory glass apparatus would not only cripple the work of the chemists, but would also influence to a serious extent certain important industries the dependence of which upon supplies of suitable glass had not at first been foreseen. In connection with these inquiries, it was at a later period considered necessary, in view of the great national interests involved, that the institute should take part in giving practical aid to would-be manufacturers. For this purpose a Glass Research Committee was appointed, and is still carrying on its work. Formulas supplied by members of the committee have been made in the laboratory of the institute and submitted to the recognised tests. The experiments have perforce been carried out on a small scale, but the co-operation of a number of glass manufacturers has been secured, and the results will be tested on a fairly large scale under complete expert control. Not the least important of the glass problems is the production of a suitable glass for miners' safety-lamps, the necessary protecting

[1] From the presidential address delivered to the Institute of Chemistry on March 1, by Prof. Raphael Meldola, F.R.S.

shades for which have also been hitherto mainly imported from abroad. This particular kind of glass is of pressing importance in relation to coal-mining, and it is certainly humiliating to learn from the makers of these lamps that for glass of the required quality capable of complying with the Home Office tests, we have been so largely dependent upon foreign glass manufacturers.

With respect to the supplies of chemical reagents, the joint committee found it necessary to entrust to a special sub-committee the somewhat arduous task of compiling a list of all the commonly used reagents with indications of the standard of purity required and the tests necessary for ascertaining whether the required standard had been reached. The list has been published as a pamphlet, and has been sent to many firms and companies of manufacturing chemists with the view of ascertaining which reagents of their own manufacture they are prepared to supply. When the replies have been received the joint committee will know the requirements of the profession could be met by British manufacturers.

It is hoped that sooner or later laboratory supplies both of apparatus and materials will be entirely of British origin. The manufacturers are—in some cases at considerable cost—developing lines of industry which are of the nature of new departures for this country. It is the duty of consumers and users—in fact, of every branch of the profession—to do their utmost to encourage and support these new home industries. Patriotism and the credit of our country alike demand that, after the war, they should help those who are helping them by insisting upon having nothing but the products of British manufacture. They should not only assist in the development of these industries now, but insure their permanent retention after the declaration of peace. With the achievement of this result there would be removed the reproach that the nation which gave to chemical science Priestley, Black, Boyle, Cavendish, Davy, Dalton, Faraday, and Graham—the country which founded the coal-tar colour industry, and which had taken the lead in the manufacture of "heavy chemicals," allowed her laboratory work to be dependent upon foreign materials, and her great textile and metallurgical industries to be threatened through the stoppage of supplies from inimical countries.

LORD KELVIN'S WORK ON GYROSTATICS.[8]

V.—*Gyrostatic Theory of Elasticity.*

[*Note.*—In the explanation of steady precession, near the foot of the first column of p. 715 of NATURE of February 25, the words, "the horizontal axis A of the couple," referred to a cut, which, owing to an accident, could not be given. But Fig. 6 there printed, and repeated here on page 21, will serve instead. In that, as indicated in the small diagram at the bottom of the figure, the axis of angular momentum—the spin-axis—is to be supposed drawn towards the right, from the centre of the gyrostat along the (horizontal) axis of rotation, and the axis of the couple horizontally from the centre towards the observer. The dotted arc, marked 90°, should be continued round to the axis marked $m\ddot{\omega}_0$. The angle 90° is that between the spin-axis and the couple-axis.—A.G.]

ONE other experiment I shall make with the veteran gyrostat, which has been spun again. You see that the rim carries two trunnions in line with the centre of the wheel (Fig. 10). These are placed on bearings attached to this square wooden frame; and now you see that as I hold the tray in my hands in a horizontal position, the gyrostat rests with its axis vertical or nearly so. The direction in which the wheel is spinning is shown by the arrow on the upper side. I now carry the tray round in azimuth in the direction of spin: nothing happens; the gyrostat spins on placidly. If, however, I carry the tray slowly round the other way, the gyrostat immediately turns upside down on the trunnions; and now, as I go on carrying the tray round in the same direction as before, the gyrostat is quiescent as at first; but the spin, by the inversion of the gyrostat, has been brought into the same direction as the azimuthal motion.

The gyrostat behaves as if it possessed volition—a very decided will of its own. It cannot bear to be carried round in the direction opposed to the rotation, and, as it cannot help the carrying round, it accommodates itself to circumstances by inverting itself so that the two turning motions are made to agree in direction. Again I reverse the azimuthal motion, and the gyrostat inverts itself so that the wheel turns in the same direction in space as at first.

The inversion brings into play a wrench on the hands of the experimenter. A varying couple, lasting during the time of the inversion, is required to reverse the angular momentum of the wheel in space, and this is applied to the gyrostat by the frame at the trunnions, and to the frame, because that is kept steady, by the hands of the operator. The total change of angular momentum is 2 N, where N is the angular momentum of the flywheel, and this is the time-integral of the couple.

It will be noticed that in this experiment, in which the gyrostat displays this curious one-sided stability and instability, it is affected by a precession impressed upon it from without. The system was not

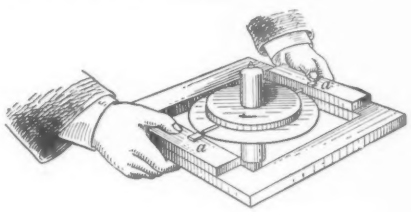

FIG. 10.

left to itself, I carried it round. The gyrostat had little or no gravitational stability—the centre of gravity was nearly on a level with the trunnions; but even if it were gravitationally unstable, sufficiently rapid azimuthal motion would keep it upright if that motion agreed with the spin, while the least motion the other way round would cause it to capsize.

It is important to notice that if the gyrostat be placed on the trunnions, so that the axis of the wheel is in the plane of the frame, azimuthal turning in one direction causes one end of the axis to rise, or turning in the other direction causes the other end to rise. As I shall show presently, this means a reaction couple on the frame which must be balanced by a couple applied by the experimenter.

Better than anything else I know, this experiment of the capsizing of the gyrostat by azimuthal motion affords an example of the two forms of solution of a certain differential equation, which, when the gyrostat is without sensible gravitational stability, and θ is small, I may write

$$A\frac{d^2\theta}{dt^2}+\omega N\theta=0,$$

where N is the angular momentum of the wheel, and ω the angular speed with which the tray was carried round. When the turnings were in the same direction, ω and N had the same sign, but when the turnings were in opposite directions the product ω N had a negative value. When the product is positive

[8] Abridged from the Sixth Kelvin Lecture, delivered at the Institution of Electrical Engineers, on January 28, by Prof. A. Gray, F.R.S. (Continued from NATURE, No. 2365, vol. xciv., p. 716.)

we have a solution giving oscillations about the vertical, in the period $2\pi\sqrt{A/\omega N}$: the equilibrium is stable. When, however, ω is reversed the product must be given the opposite sign, and we get a solution in real exponentials, starting falling-away from the upright position, which is continued until the opposite (stable) position is attained. N has now also been reversed in space, and the product ωN in the differential equation is again positive.

As I have already stated, the time integral of the turning motive about the vertical required by the gyrostat from the frame constraining it to move round in azimuth is $2N$; that is, $2Cn$, where C is the moment of inertia of the flywheel about its axis. There is thus at each instant of the turning in azimuth before the inversion has been completed a couple required from the frame, and this couple is greater the greater the angular speed n of spin.

The couple arises thus. Let the gyrostat axis have been displaced from the vertical through an angle θ about the trunnion axis. In consequence of the azimuthal motion, at rate ω, say, the outer extremity of the axis of angular momentum is being moved parallel to the instantaneous position of the line of trunnions, and thus there is rate of production R of angular momentum about that line; but there being no applied couple about the trunnions, the gyrostat must begin to turn about the trunnions to neutralise R. This turning tends to erect or to capsize the gyrostat according as the spin and azimuthal motions agree or are opposed in direction. In its turn, however, this involves production of angular momentum about the vertical for which a couple must be applied by the frame, and of course to the frame by the operator. This couple is greater the greater Cn, and therefore if the operator cannot apply so great a couple, an azimuthal turning at rate ω cannot take place. With sufficiently great angular momentum the resistance to azimuthal turning could be made for any stated values of θ and ω greater than any specified amount.

The magnitude of this couple which measures the resistance to turning at a given rate is greatest when the angle θ is 90°; that is, when the axis of the flywheel is in the plane of the frame.

Now I come to an interesting application of these ideas. You are aware that Lord Kelvin endeavoured to frame something like a kinetic theory of elasticity—that is, he conceived the idea that, for example, the rigidity of bodies, their elasticity of shape, depends on motions of the parts of the bodies, hidden from our ordinary senses, as the flywheel of a gyrostat is hidden from our sight and touch by the case. Look at this diagram of a web (Fig. 11). It represents two sets of squares, one shown by full, the other by fine, lines; the former are supposed to be rigid squares, the latter flexible. Unlike ordinary fabrics, which are almost unstretchable except in a direction at 45° to the warp and woof, this web is equally stretchable in all directions. If the web is strained slightly by a small change of each flexible square into a rhombus, or into a not-square rectangle, the areas are to the first order of small quantities unaltered.

Now imagine that a gyrostat is mounted in each of the rigid squares, so that the axis of the trunnions and the axis of rotation are in the plane of the square as shown in Fig. 12. If the angular speeds of the flywheels are sufficiently great, it is impossible to turn the squares in azimuth at any given small angular speed. Thus any strain involving turning of the small squares is resisted, and we have azimuthal rigidity conferred on the web by the gyrostats. There is, however, no resistance to non-rotational displacement of the squares as wholes.

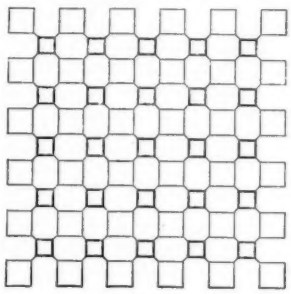

FIG. 11.

To get a model in three dimensions Lord Kelvin imagined an analogous structure made up of cubes, each composed of a rigid framework to play the part of the squares, and connected by flexible cords joining adjacent corners of the cubes. In each cube he supposed mounted three gyrostats with their trunnions at right angles to the three pairs of sides. This arrangement would, like the web of squares, resist

FIG. 12.

rotation, but now about any axis whatever; and there would be no resistance to mere translation of the cubes as wholes. Thus the body so constituted would be undistinguishable from an ordinary elastic solid as regards translatory motion, but would resist turning.

It is convenient in this connection to refer to an arrangement—a gyrostatic imitation of a spiral spring—in which a constant displacement is produced and maintained by the action of a constant force in a fixed direction, involving the application of a couple of constant moment, though not of constant direction of axis. This gyrostatic spring balance is indicated in a paper entitled "On a Gyrostatic Adynamic Constitution for Ether," published partly in the *Comptes rendus*,[9] and partly in the Proceedings of the Royal Society of Edinburgh.[10] This is one of the many papers which Lord Kelvin published in the latter part of his life on a question that occupied him much from time to time, the nature of the æther as a vehicle of light and as the medium in which electric and magnetic phenomena are manifested.

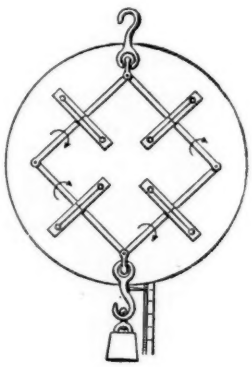

FIG. 13.

The spring balance is described in some detail in his "Popular Lectures and Addresses."[11] I had thought of realising the arrangement, which is shown in Fig. 13, but on consideration I found that though it would act as a spring, it would not, except under certain conditions, not easily realisable even approximately, possess the peculiar property of a spiral spring of being drawn out a distance proportional to the

[9] *Comptes rendus*, vol. cix., p. 453, 1889. Math. and Phys. Papers, vol. iii., p. 466.
[10] Proceedings of the Royal Society of Edinburgh, vol. xi., 1890.
[11] Vol. i., p. 237, *et seq.*

weight hung on the lower hook. The gyrostatic arrangement is very difficult to realise with ordinary gyrostats, but presents no difficulty with our motor instruments. You see what the arrangement is. A frame of four equal bars is constructed, by jointing the bars freely together at their extremities in the manner shown by the diagram. It is hung from a vertical swivelling pin at one corner, so that one diagonal of the frame is vertical, and another vertical swivelling pin at the lowest corner carries a hook. Four equal gyrostats are inserted, one in each bar, as shown, with its axis along the bar, and they have equal rotations in the directions shown by the circular arrows. Under the couples tending to change the directions of the axes of the flywheels, and applied by the weights of the gyrostats and bars, the system precesses round the two swivels, and so preserves a constant configuration. If now a weight is hung on the hook at the lower end, the frame is elongated a little, and a new precessional motion gives again a constant configuration of the frame, different, of course, from the former one. Two gyrostats, the upper or lower pair, would serve quite well to give the effect.

Lord Kelvin suggested that if the frame were surrounded by a case, leaving only the swivel-pins at top and bottom protruding, it would be impossible, apart from special knowledge of the construction of the interior, to discern the difference between the system and an enclosed spiral or coach spring, surrounded by a case and fitted with hooks for suspension and attachment of weights. But unless the masses of the gyrostats are very small (while their angular momenta are exceedingly great), so that the change of kinetic enegy due to the change in precessional motion may be put down entirely, or nearly so, to the work done by gravity on the weight carried by the hook, in its descent from one configuration of steady motion to another, the distance through which the frame is lengthened is not simply proportional to the load applied.

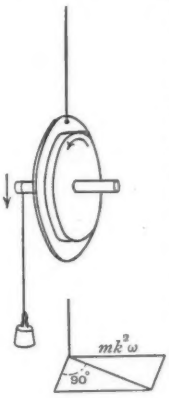

FIG. 6.

A fair idea of the action, and, indeed, an approximate realisation of the property aimed at, is obtained by means of the arrangement shown in Fig. 6 above. We have had it before. A gyrostat is hung with its axis horizontal by a cord in the same vertical as the centroid. The flywheel spins, but as there is no couple there is no precession. A weight $m\,g$ is applied in a vertical line at distance l from the centroid, as indicated by the diagram; a slight, very slight, tilting of the gyrostat is produced, and the gyrostat moves off with not quite steady precession, of average angular speed μ. Neglecting the slight deviation now set up of the suspension cord from the vertical, and putting A for the moment of inertia of the gyrostat about a vertical axis through its centre, we get for the kinetic energy of the azimuthal motion the value $\frac{1}{2}\mathrm{A}\,\mu^2 + \frac{1}{2}m\,l^2\,\mu^2$. The work done by the weight $m\,g$ in its descent through the small distance h involved in the tilting is $m\,g\,h$. Hence we get $\frac{1}{2}(\mathrm{A}+m\,l^2)\,\mu^2 = m\,g\,h$.

As we have already seen, however, we have in this case $\mu = m\,g\,l/\mathrm{C}\,n$. Substituting in the equation just found this value for μ, and supposing that A is great in comparison with $m\,l^2$, so that the term $\frac{1}{2}m\,l^2\,\mu^2$ may be neglected, we find after a little reduction the equation—

$$\frac{m}{h} = 2\frac{\mathrm{C}^2\,n^2}{\mathrm{A}\,l^2 g}.$$

Thus h is proportional to m.

It will be evident that if on the right-hand side of the first equation there had been terms due to descent of the gyrostat through a distance of $\frac{1}{4}h$ or $\frac{3}{4}h$, this equation of proportionality could not have been obtained.

The idea, however, underlying the arrangement is very suggestive, and carries us a long way towards obtaining a definite notion as to how the elastic properties of bodies may be explained.

(A gyrostatic pendulum was here shown. See for figure and description NATURE, April 17, 1913.)

VII.—*Vibrations and Waves in Stretched Chain of Gyrostats.*

[An account of this paper was given in the lecture, and will be found (with details of the mathematical discussion appended) in the *Journal* of the Institution of Electrical Engineers.]

VIII.—*Gyrostatic Observation of Rotation of the Earth.*

The famous French experimentalist, Léon Foucault, suggested two ways of determining the rotation of the earth. One was observation of the apparent turning of the plane of vibration of a long pendulum, suspended so as to be as nearly as possible free from any constraint due to the attachment of the pendulum wire to its fixed support. This classical experiment was carried out with fair success at the Panthéon at Paris, and was repeated under the domes of the cathedrals of Amiens and Rheims. If the exponents of "Kultur" in Northern France were aware of this fact, they seem to have attached to it just as little weight as they gave to the more sacred associations of the beautiful old church of the latter city.

Foucault's other method was based on the fact that a gyrostat, if mounted properly, retains unaltered the direction of the spin-axis when the supports are turned round. Here, for example, is our pedestal gyrostat, mounted freely in its enclosing frame which is carried by a vertical rod, swivelling in a vertical socket carried by the supporting stand (see Fig. 7 above). I can set the spinning gyrostat with its axis in any direction I please, and, when I turn the supporting stand round, a friction couple of some little magnitude is applied to the vertical rod. You see that I do not alter the direction of the spin-axis perceptibly. Yet the friction couple is sufficient to carry the gyrostat round with the stand when there is no spin. The spin results in a great increase of virtual inertia for turning displacements, as we shall see quantitatively in the case of one of Lord Kelvin's experiments, which I am about to describe.

In practice it is found desirable to subject the gyrostatic apparatus to a constraint which is perfectly definite; for example, the axis of spin may be kept horizontal. Solutions of the problem are to be found in the gyrostatic compasses now in use on the warships of various navies.

At the British Association meetings at Southport and Montreal, in 1883 and 1884, Lord Kelvin suggested methods of demonstrating the earth's rotation, and of constructing a gyrostatic compass. One of these had reference to the component of rotation about the vertical, the component, in fact, demonstrated by the Foucault pendulum experiment. If ω be the resultant angular speed, the component about the vertical at any place in latitude l is $\omega \sin l$, while

the companion component about the horizontal there is $\omega \cos l$. Thus at London the component about the vertical is 0·78 of ω, and the period of rotation about the vertical is about 30·77 hours of sidereal time.

Lord Kelvin's method of measuring $\omega \sin l$ consists in supporting a gyrostat on knife-edges attached to the projecting edge of the case, so that the gyrostat without spin rests with the axis horizontal or nearly so. For this purpose the line of knife-edges is laid through the centre of the flywheel at right angles to the axis, and the plane of the knife-edges is therefore the plane of symmetry of the flywheel perpendicular to the axis. The knife-edges are a little above the centre of gravity of the instrument, which we suppose in or nearly in that plane, so that there is a little gravitational stability. The azimuth of the axis is a matter of indifference, as any couple due to the component of rotation about the horizontal is balanced by an equal couple furnished by the knife-edge bearings.

At points in a line at right angles to the line of knife-edges, and passing through it, two scale-pans are attached to the framework, and by weights in these the axis of the gyrostat (without spin) is adjusted, as nearly as may be, in a horizontal position which is marked. The gyrostat is now removed, to have its flywheel spun rapidly, and is then replaced. It is found that the weights in the scale-pans have to be altered now to bring the gyrostat back to the marked position. From the alteration in the weights the angular speed about the vertical can be calculated.

To fix the ideas, let the gyrostat axis be north and south, and let the spin to an observer, looking at it from beyond the north end, be in the counter-clock, or positive direction. The rotation of the earth about the vertical carries the north end of the axis round towards the west, and therefore angular momentum is being produced about a horizontal axis drawn westward, at a rate equal to $C n \omega \sin l$, where C is the angular momentum of the flywheel. If the sum of the increase of weight on one scale-pan and the diminution (if any) in the other be w, and a be the horizontal distance between the points of attachment of the scale-pans, we have

$$C n \omega \sin l = w g a.$$

Thus if C and n are known, $\omega \sin l$, or ω, can be calculated.

Lord Kelvin does not give any figures as to the forces to be measured in a practical experiment; but I can supply these. We may take the mass of a small flywheel as 400 grammes, its radius of gyration as 4 cm., and its speed of revolution, if high, as 200 revolutions per second. If we take a as 10 cm. we obtain for London the equation

$$400 \times 4^2 \times 400\pi \times \frac{2\pi \times 0{\cdot}78}{80160} = 10 \times 981 \times w.$$

This gives $w = 0{\cdot}047$ gramme, or 47 milligrammes. It would require careful arrangements to carry out the experiment accurately, but the idea is clearly not unpractical. With some of the new gyrostats that we now have, the mass of the wheel is as much as 2000 grammes, and the radius of gyration is about 7·5 cm. These numbers bring w up to 0·82 gramme, at the same speed.

If the gravitational stability of this gyrostatic balance be removed, that is, the line of knife-edges be made to pass accurately through the centre of gravity of the system of wheel and framework, and the axis of the wheel be placed in a truly north and south vertical plane, so that the knife-edges are horizontally east and west, the gyrostat will be in stable equilibrium when the axis is parallel to the earth's axis, and is turned so that the direction of rotation agrees with the rotation of the earth. For we have then simply the experiment, described above, of the gyrostat mounted on trunnions resting on bearings attached to a tray which is carried round by the experimenter. The axis of the gyrostat was at right angles to the tray, and we saw that when the tray, held horizontally, was carried round in azimuth the equilibrium of the gyrostat was stable or unstable, according as the two turnings agreed or disagreed in direction. In the present case the tray is the earth, the position of the axis of rotation parallel to the earth's axis replaces the vertical position, and the earth's turning the azimuthal motion. If displaced from the stable position the gyrostat will oscillate about it in the period $2\pi\sqrt{A/C\, n\omega}$, where A is the moment of inertia about the knife-edges, and the other quantities have the meanings already assigned to them.

If the line of knife-edges be north and south, the vertical will be the stable, or unstable, direction of the axis of rotation, and there will be oscillation about the stable position in the period

$$2\pi\sqrt{A/C\, n\omega \sin l}.$$

The gyrostat thus imitates exactly the behaviour of a dipping needle in the earth's magnetic field, and thus we have Lord Kelvin's gyrostatic model of the dipping needle.

It is right to point out that these arrangements were anticipated by Gilbert's barogyroscope,[12] which rests on precisely the same idea, and applies it in a similar manner.

IX.—*Gyrostatic Compass.*

At Montreal Lord Kelvin described a "gyrostatic model of a magnetic compass." This was one of his gyrostats hung, with its axis of rotation horizontal, by a long fine wire, attached to the framework at a point over the centre of gravity of the system, and held at the upper end by a torsion-head capable of being turned round the axis of the wire. By means of this torsion-head any swinging of the gyrostat in azimuth round the wire was to be checked until, when the head was left untouched, the gyrostat hung at rest.

In small azimuthal oscillations of the gyrostat about the axis of the wire, the wire being fixed to the gyrostat at the lower end and held by the head at the upper, the virtual moment of inertia of the gyrostat about the wire is greatly enhanced by the rotation of the flywheel If there were no rotation the moment of inertia would be A; with rotation it is virtually $A(1+C^2n^2/A\,M\,a\,g)$, where M is the whole suspended mass, a the distance of the point of attachment of the wire above the centre of gravity of the mass M. This will be found proved very simply in the Mathematical Appendix [see *Journal*, I.E.E.] to this lecture. It will be shown, moreover, that when the whole motion is considered—the tilting motion as well as the azimuthal—it appears that there are two fundamental periods of vibration. There is the long period due to the slight torsional rigidity of the long wire, and the enhanced moment of inertia pointed out by Lord Kelvin, and also a short period, the shortness of which is most properly to be reckoned as due to virtual diminution of the moment of inertia of the gyrostat, in the tilting motion, in exactly the same ratio as the other moment of inertia is increased. Both these periods are separately possible, and in

[12] "Mémoires sur divers problèmes," etc. *Annales de la Société Scientifique, Bruxelles*, 1877—8.

the most general motion they are superimposed. This second curious effect was not referred to by Lord Kelvin, and I have not seen it noted before. The co-existence of long and short periods is, however, characteristic of rapidly spinning gyrostatic systems.

Now suppose that the wire so long and of so slight torsional rigidity that this rigidity cannot stabilise the gyrostat in the position of unstable equilibrium. Then the effect of the component of rotation of the earth about the vertical is to produce tilting of the axis of the flywheel from the horizontal position, since this turning gives a rate of production of angular momentum about a horizontal axis at right angles to that of rotation. A slight tilt suffices to give an equilibrating couple, and so we can have the gyrostatic axis in a north and south vertical plane, and nearly horizontal, while the wire is without twist. Into this position the gyrostat is guided by manipulation of the torsion-head. The effect of the horizontal component of the earth's angular speed is now practically zero.

If now by the use of the torsion-head the gyrostat axis be brought to rest in a nearly horizontal position at an angle ϕ with the north and south horizontal direction, the component of turning about this position of the axis is $\omega \cos l \cos \phi$, and about a horizontal line at right angles to the new position of the axis is $\omega \cos l \sin \phi$. The former has no influence on the gyrostatic axis, the latter gives a rate of production of angular momentum about the vertical amounting to $C n \omega \cos l \sin \phi$. Hence a couple of moment equal to this must be applied by means of the torsion-head to produce equilibrium, and this as we see is proportional to $\sin \phi$.

X.—*General Dynamical Theory of Gyrostatic System with any Number of Freedoms.*

I cannot do more than mention the gyrostatic investigations contained in the second edition of "Natural Philosophy." These were written while the proofs of § 345 of the book were in his hands, and consist of additional sections (§§ 345^{i}–345^{xxviii}) interpolated at that stage. From many points of view this part of the book is exceedingly interesting. It continues a subject which was also expanded in the same way on the proof-sheets (in §§ 343*a*–343*m*), that of oscillatory motion. Oscillatory motion for systems of two, three, four, six, or more freedoms with gyrostatic domination is enough to tax the skill of the most expert analyst, for questions arise regarding the roots of the determinantal equations and their interpretation, which require great care in handling. I may only quote the general conclusions as to gyrostatic domination.

Let the number of the freedoms be even (that is, the freedoms exclusive of those by which the flywheels have angular momenta about their axes). Let the equilibrium of the system when at rest (without spin of the flywheels) be either stable, or unstable, for every freedom. If the wheels are so linked up to the system as to render gyrostatic domination possible, then with sufficiently rapid spin the equilibrium becomes stable, with half the whole number, $2n$ say, of its periods of vibration exceedingly small, and the other half very large. Each set of periods is given by the roots of a determinantal equation of degree n. The latter periods are to the first degree of approximation independent of the applied forces, and were called "adynamic," the former periods were called "precessional," and do depend on the applied forces.

The first approximations to the fast and slow azimuthal motion of a top are in point. The angular speed $C n/A \cos \theta$ does not depend on any applied forces, the other speed $M g h/C n$ does.

XI.—*Difficulties of Mechanical Hypotheses and Models. Conclusion.*

I have now dealt with most of Lord Kelvin's investigations and theories. These were related in many ways to electricity and magnetism, and in all of them he ever sought some dynamical explanation that would work. This, indeed, was the distinguishing feature of all his researches, the bringing of everything down to dynamics, and the construction where possible of illustrative mechanical models. Electricity and magnetism are highly dynamical affairs; we send signals by wire or "wireless," we transmit power in a wonderful manner by an agency which we are still far from completely understanding, an agency which causes absorption of energy at one place on the earth's surface, and evolution again of a large portion of that energy at another place. The vehicle is the æther, for, in spite of all that I have been able to learn regarding the new theory of relativity, I still believe in the æther's existence. In all this we are held fast by dynamical laws, no doubt not yet formulated in full detail, but to a considerable extent already correctly comprehended.

* * * * * *

Lord Kelvin certainly had confidence in his own theories and clung firmly to his conclusions. He was *tenax propositi*, yet he could on occasion acknowledge that he had made a mistake. His genius ranged over the whole field of physical science; no problem was too great or too small to attract his attention. No obstacles, no complications, daunted his spirit of inquiry. The thunders of Jove, the birth of the world and the cold death prepared for it by dissipation of energy, the harnessing of the energies of nature for the service of man, the guidance and safety of mariners, the genesis of waves and their breaking into spray and spindrift, all these questions, and many others, engaged his thoughts, to the lasting benefit of humanity and the increase of knowledge. Throughout all he was keen and calm and dispassionate, a truly unaggressive and kindly natural philosopher.

The function of science is to enable man to penetrate the secrets of nature, and to apply that knowledge to the promotion of the welfare and happiness of all living beings. No one would have repudiated with more scorn than Lord Kelvin that emanation of the Pit, the modern doctrine that culture—scientific, philosophical, or artistic—entitles a self-appraised and self-chosen nation to wade through seas of blood to the domination of the world.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LONDON.—The report of the Military Education Committee to the Senate of the University for the year 1914 shows that very valuable service has been rendered to the country by the University Contingent of the Officers Training Corps. The number of cadets and ex-cadets of the Contingent gazetted to commissions between August 5, 1914, and the end of the year was 773, and the number of graduates and students of the University (not being past or present cadets of the O.T.C.) gazetted to commissions during the same period was 156. Allowing for officers commissioned from the O.T.C. before August 5, the total number of officers now serving, who are ex-cadets of the University of London O.T.C., or were recommended for their commissions by the University, is estimated at 1100. In addition, a large number of graduates and students of the University have been granted commissions through other channels or are

serving in the ranks. We notice with regret that the following officers who proceeded to commissions from the University of London O.T.C. are reported killed:—2nd Lieut. T. R. Bottomley, Birkbeck College; 2nd Lieut. J. S. Paulson, University College; Lieut. C. D. Sneath, University College; 2nd Lieut. C. F. Shaw, King's College; 2nd Lieut. M. A. P. Shawyer, East London College; and 2nd Lieut. P. J. Whitehouse, East London College.

The Commanding Officer of the University O.T.C. Lieut.-Col. D. S. Capper, announces that a limited number of young men who are not students of the University will be enrolled for a course of continuous training with the view of qualifying for commissions. Candidates, who must be between the ages of 18 and 28 and suitable in every respect for commissions in the Army, should attend in person to see the Adjutant of the Contingent at the Headquarters, University of London, South Kensington. The next course of continuous training will commence on March 15.

The Senate on February 24 appointed Dr. C. K. Tinkler, D.Sc. (Birmingham), to the readership in chemistry, tenable in the home science department of King's College for Women.

The D.Sc. degree in biological chemistry was granted to R. V. Norris (Lister Institute), and in physics to A. H. Ferguson.

AN interesting series of special lectures dealing with questions of social service is at present being conducted at the Municipal Technical Institute, Belfast. The problems created by the war have aroused much interest in social work, and have attracted into the field of social service large numbers of voluntary workers. Amongst these workers the need is being increasingly felt for a better understanding of the principles which should be followed and of the methods which should be employed in social effort, as well as for a fuller knowledge of the local facilities already existing for the amelioration of distress. It is to meet the urgent call for such knowledge that the authorities of the institute have established the lectures. The programme of the series, issued in pamphlet form and containing abridged syllabuses, shows that the course takes a very comprehensive view of the whole subject. The lectures fall naturally into three main groups. The first group deals with fundamental and general questions relating to social service, the second group deals with municipal and State effort, and the third group treats of voluntary agencies. The value of the programme is enhanced by the inclusion of lists of the books on social subjects which are available in the library of the institute and in the public libraries of the city. The first lectures of the series have been exceptionally well attended, and it is hoped that the outcome of the series will be the establishment of systematic courses of instruction in various branches of social science. More than six hundred members of the staff and of present and former students of the institute are serving with the naval and military forces of the Empire.

THE debate in the House of Commons on Friday last on the vote for the Civil Service and Revenue Department was mainly occupied with the question of the alleged shortage of adult labour in agricultural districts and the attempt of farmers to induce the Boards of Agriculture and of Education to look with favour on the exploitation of children to take the place of men who have enlisted. It is satisfactory to learn that neither of the Boards in question shows much inclination to relax the conditions under which children are now allowed to leave school for full-time work, yet it is nevertheless disquieting to find that in some rural areas it is almost impossible to get magistrates to convict for breaches of the school bye-laws. The results of the war have not placed farmers in a disadvantageous position as regards prices; on the contrary, as is well known, the price of wheat and other produce has almost doubled since the war began, and the farmer has thus little reason to refuse a substantial advance in wages such as would induce the labourer in the town to return to the countryside. Moreover, the question as to whether there is a material shortage is not beyond doubt, since it is stated that not more than three per cent. of farm labourers have joined the forces. The cry for child labour comes mainly from the southern counties, where it is admitted that the rate of payment is greatly below that of the north and in Scotland. In any case, before the child is exploited the labour of women at an adequate rate demands to be considered. Having regard to the fact that this war is making a heavy drain upon some of the best elements of the industrial population the nation cannot be indifferent to the well-being of the children, both physically and intellectually. Everything that is possible, no matter how great the sacrifice of material interests, should be made to conserve both. We are at war with the best-instructed nation of the world, and we cannot be too considerate of the present welfare of the nation's children, having regard to the heavy responsibility the future will place upon them.

THE second reading of the Universities and Colleges (Emergency Powers) Bill was agreed to by the House of Commons on Tuesday, March 2. The Bill gives the Universities of Oxford and Cambridge power to postpone the date of the determination of scholarships in order to enable their holders to enjoy them when they return from the war. In the same way, power is given to suspend the statutory conditions as to residence; to enable the richer colleges to make up the deficit in the tutorial fees by taking money from their endowments, and the poorer colleges to postpone repayment of capital; the power to make emergency statutes, and so on. In moving the second reading of the Bill, Mr. Asquith said that the total number of members from each University serving in the Army and at the front is approximately 6000. The total number of undergraduates in residence at Cambridge a year ago was 3181. It is now 1227. The figures for Oxford are approximately the same. This means that two-thirds of the undergraduates from the two great Universities have volunteered for service, and are now serving their country in the Army. Nearly all the physically fit undergraduates in residence both in Oxford and Cambridge have joined the Officers Training Corps, and many of the University buildings have been given up for military purposes. This transformation in the whole aspect and conditions of university life has exposed both the Universities as a whole and their constituent colleges to great difficulties and pecuniary embarrassments. At Cambridge the fees normally payable in the scientific department of the University are 26,000*l.* a year; and it is estimated that this year less than 15,000*l.* will be paid; while other fees, usually amounting to 35,000*l.*, the University authorities estimate will be no more than 15,000*l.* In supporting the Bill, Sir Joseph Larmor said that when the war is over it will be the duty of the country to see that the standard of British learning and science is maintained before the world. It will be the duty of this nation more than ever before to see that the things of the mind are attended to after we have obtained success in the material prosecution of the war.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 25.—Sir William Crookes, president, in the chair.—Prof. L. **Hill** and J. F. **Twort**: The effect of the depth of pulmonary ventilation on the oxygen in the venous blood of man.—J. **Barcroft** and Toyojiro **Kato**: The effect of functional activity upon the metabolism, blood flow, and exudation in organs. The organ studies have been skeletal muscle and the submaxillary gland. (1) The oxygen used by these organs not only increases during their activity but outlasts it by some hours. The curve of oxidation usually shows two maxima, the first during the period of activity, the second much later. (2) water leaves the blood-vessels in much greater quantities during and after activity of the organs than before; a similar second maximum is sometimes seen in the case of the exudation. (3) In the case of muscle not all the exudation leaves the muscles as lymph. Of the right and left gastrocnemius muscles, the one which has been stimulated is heavier several hours after the stimulation, and of lower specific gravity than the unstimulated one. (4) The dilatation of the vessels of the organ outlasts the functional activity for two hours or more in the case of muscle which has been stimulated rhythmically for fifteen minutes. (5) The tenseness of the muscle caused by its distension with water would seem to be the physical basis of stiffness.—Miss D. Jordan **Lloyd**: The osmotic balance of skeletal muscle. In order to free the phenomena as far as possible from complications due to the formation of diffusion columns, a very small flat muscle—the sterno-cutaneous of the frog—was used. The results of experiments show that an oxygen-saturated muscle has an osmotic equivalent less than that of distilled water.—Dr. A. J. **Ewart**: The function of chlorophyll. Previous observations of the author have tended to support the theory that chlorophyll is a stage in photosynthesis. The present paper develops this idea further. By means of Wellstätter's methods of extraction and separation, chlorophyll, carotin, and xanthophyll were obtained in the pure state and used for the experiments. The following conclusions were reached:—(1) No peroxides, organic or inorganic, are produced during the photo-oxidation of chlorophyll, xanthophyll, and carotin. The oxidising effect of these latter substances on potassium iodide when they are undergoing oxidation in the light is due to the fact that in the presence of abundant oxygen they can act as oxidases, not only to themselves, but also to substances with which they may be in contact, such as hydriodic acid, litmus, or guaiacum. (2) Chlorophyll and xanthophyll decompose during photo-oxidation into (*a*) solids, and (*b*) a gas. The solids are colourless, waxy substances and hexose sugars. The gas is formaldehyde gas. With dry films in dry air free from CO_2 relatively more formaldehyde is produced and less sugar. (3) Carbon dioxide combines with chlorophyll, forming xanthophyll and a colourless waxy solid. The combination only takes place actively in the presence of water, and is accelerated by sunlight.—A. **Compton**: The influence of the hydrogen ion concentration upon the optimum temperature of a ferment.—M. **Back**, K. M. **Cogan**, and A. E. **Towers**: Functional œdema in frogs. If the gastrocnemius muscle of a frog be stimulated for fifteen minutes with forty induction shocks per minute it becomes heavier than the other. The difference in weight may amount to upwards of 20 per cent. of the weight of the muscle. The specific gravity falls correspondingly. This phenomenon may be noticed from fifteen minutes after the stimulation ceases to six hours. After sixteen hours the œdema has passed off.

Physical Society, February 12.—Dr. A. Russell, vice-president, in the chair.—A. **Campbell Swinton**: A galvanic cell which reverses its polarity when illuminated. If two plates—one of zinc and the other of tinned copper coated on one surface with selenium and varnished with enamel over the remainder of its surface—are immersed in tap-water, the electric current through a galvanometer connected to the plates shows that in the dark the zinc is electro-positive to the selenium, while the result of light falling on the selenium is to increase the effect. If, however, instead of zinc, carbon or copper is employed for the non-coated plate, the interesting result is obtained that, while the selenium proves to be electro-positive to the carbon or copper in the dark, it immediately becomes electro-negative to carbon or copper the moment it is illuminated, this being easily shown by the deflections of the galvanometer in contrary directions as the light is turned on and off.—Prof. S. P. **Thompson**: On the criterion of steel suitable for permanent magnets. Whatever the form to be given to a permanent magnet, the prime requisites as to the quality of the steel are (1) large remanent magnetism ($\mathfrak{I}_{rem.}$) and a high coercive (force $\mathcal{H}_c$). Since Hopkinson's determinations of 1885 it has been supposed that for the purpose of making permanent magnets the best material would be that for which both of these quantities and, consequently, their numerical product, should be as high as possible. Recently Mr. J. A. Mathews and, independently, Mr. J. R. Ashworth, have proposed to take the ratio $\mathcal{H}_c \div \mathfrak{I}_{rem.}$ or $\mathcal{H}_c \div \mathfrak{B}_{rem.}$, which only differs in scale as the criterion. To decide as to the suggestion to take the ratio instead of the product a table giving the values of $\mathcal{H}_c \mathfrak{I}_{rem.}$ $\mathcal{H}_c \div \mathfrak{I}_{rem.}$ and $\mathcal{H}_c \times \mathfrak{I}_{rem.}$ for a number of steels is given, and it is clearly shown that the use of the ratio as a criterion of magnetic usefulness leads to most absurd results. As an example, annealed manganese steel (almost non-magnetic) should, judging from the ratio, be six times as good as Remy steel, whereas in reality, for equality of pull, a magnet of manganese steel would require to be 312 times the weight of that made of Remy steel. The qualities requisite in an ideal steel for permanent magnets are indicated.—A. B. **Wood** and A. I. **Steven**: An investigation of the photographic effect of recoil atoms. The ionising, phosphorescent and photographic effects of the α-particles from a radio-active substance entirely cease when the particle still retains about 40 per cent. of its kinetic energy. It appears possible, therefore, that the recoil atoms from a radio-active source should be able to affect a photographic plate, for though the range of a recoil atom is only about 1/500th of that of the α-particle shot off from it, the ionising effect has been shown by Wertenstein and one of the authors to be 10 times as powerful over the corresponding range as that of the α-particle. Attempts have, therefore, been made to demonstrate this action in the case of the recoil atom from polonium, this substance being chosen on account of the inactive nature of the recoiling atom. Two distinct methods were employed: (1) The recoil atom was "absorbed"; (2) the difference of deflection of the α-particle and the recoil atom in a strong magnetic field was utilised in order to attempt to separate their effects. "Schumann" plates were used as being most easily penetrable, but in all cases the results were negative or inconclusive. This is probably due to the fact that the recoil atoms are not able to penetrate sufficiently deeply into the sensitive layer to render the grains developable.

Linnean Society, February 18.—Prof. E. B. Poulton, president, in the chair.—Harold **Wager**: The action of light upon chlorophyll. By making a film of chlorophyll upon paper and on glass, by floating an alcoholic solution, and allowing it to dry, the author was able to bleach a portion under strong sunlight, and covering a portion by black paper; when this was tested by Schiff's solution, the exposed, that is, the bleached portion, became pink, the unexposed portion showing no colour change. Another experiment was made by subjecting similarly bleached portions of chlorophyll to the action of potassium iodide, when the exposed parts turned reddish-blue, in consequence of the liberation of iodine, which acts upon the starch on the paper. The experiments clearly show that the decomposition of chlorophyll is accompanied by the formation of an aldehyde and of something able to oxidise the potassium iodide and to set free the iodine. Instead of alcoholic extract of chlorophyll we may use dried leaves, or chlorophyll expressed from leaves, or layers of Euglena or algæ spread over the paper. The reactions also take place inside a leaf, if the bleaching has been efficient. Thus if sunlight is condensed by a lens upon a living leaf of *Oxalis acetosella* containing plenty of starch, the chlorophyll is bleached in a small area, and if treated with Schiff's solution, a strong aldehyde reaction results; if tested with potassium iodide the said area becomes blue. It having been stated that formaldehyde is produced when chlorophyll is exposed to sunlight in the presence of carbon dioxide, an attempt was made to determine whether such was the case in the present series of experiments, but the author was not able to satisfy himself on this point, though several of the tests succeeded even with so small an amount as one-millionth of formaldehyde. Hydrogen peroxide had been suggested as the gaseous oxidising compound of chlorophyll, but the result of many varied tests showed that this was not so.

MANCHESTER.

Literary and Philosophical Society, February 9.—Mr. F. Nicholson, president, in the chair.—Dr. T. Graham **Brown**: Note on the physiology of "walking," with especial reference to its occurrence in the unborn fœtus of the cat. The various reflexes have been examined in cat fœtuses. The red nuclei seem to be capable of stimulation, and evoke their characteristic movements of the fore-limbs. The limb reflexes are very similar to those of the adult cat. The ipsilateral flexion-reflex and the contralateral extension-reflex have thus been observed. In the former reflex an extension rebound effect has been seen. Reflex inhibition may be observed on pitting one reflex against another. If the fœtus is shelled out of the uterus without delay into warm physiological salt solution it may be regarded as still unborn. In these circumstances unmistakable movements of progression may be obtained on producing asphyxia by pressure upon the umbilical cord. They may sometimes appear to arise spontaneously. This observation shows that the mechanism for co-ordinate progression develops during intra-uterine life, and that the co-ordination of the mechanism is not conditioned after birth by a process of "learning." The observation also shows that the rhythmic activity may be evoked by the general stimulus of asphyxiation before it has been evoked or conditioned by any rhythmic self-generated peripheral stimuli such as those which play an important part in normal progression, but have been shown not to be its intrinsic factors. It thus also gives another demonstration of the similarity between the respiratory mechanism and that for progression.—Prof. G. Elliot **Smith**: The Darling Downs skull. Photographs were shown of a completely mineralised human skull, which had been found near Warwick in the Darling Downs of Queensland, and was described by Profs. Edgeworth David and Wilson at the recent meeting of the British Association in Australia. This important discovery of the earliest human remains yet known in Australia seems to prove that Man reached Australia at a time when the great fossil marsupials were still living.

DUBLIN.

Royal Dublin Society, February 23.—Prof. Wm. Brown in the chair.—Prof. Grenville A. J. **Cole**: The mode of occurrence and origin of the orbicular granite of Mullaghderg, Co. Donegal. The structure and mineral characters of this rock were described by Dr. F. H. Hatch in 1888. A recent visit by the Geological Survey has enabled large specimens to be procured, the surfaces of which have been polished. The nucleus in several of the large spherulites is seen to be a flake of schistose rock. In most cases, however, it consists of granite, somewhat poorer in biotite than the granite which includes the spherulitic bodies. The very local occurrence of this orbicular rock as a variation on the general red granite of the district leads to the conclusion that the spherulitic bodies represent inclusions from the roof of Dalradian schists which once overlay the granite cauldron. Such inclusions may have fallen in from a cold portion of the roof and thus promoted a rapid crystallisation of oligoclase round about them by interaction of their constituents and those of the granite magma. Blocks of already cooled granite may have fallen back also from the roof of the dome, and may have supplied nuclei for spherulitic growth. The occurrence of granite round about schist-fragments, and surrounded by a zone of radial oligoclase, suggests, however, an interchange of material between the granite and the schists. Granitic material seems to have soaked in while more basic material moved outwards to form the radially crystalline zone. Experiments by Tenow and Benedicks and by Endell are referred to; but no explanation can be offered as to why orbicular structure is so rare a phenomenon.

EDINBURGH.

Royal Society, February 1.—Sir E. A. Schäfer, vice-president, in the chair.—Mrs. Rosalind **Jones** (*née* Crosse): Studies on periodicity in plant growth. Part ii. Correlation in root and shoot growth. In a former paper the fact of a four-days' periodicity in plant growth had been established; and in the present continuation the subject was further investigated. It was found that artificial changes in environment as regards heating and illumination did not affect the periodicity, and that there was correlation in the root and shoot growths.—Dr. J. **Dawson**: The histology of disseminated Sclerosis. This investigation, which had been partly outlined by the late Dr. Alexander Bruce, was based on an extended pathological observation disseminated sclerosis. This investigation, which had been studied largely by the method of serial sections stained by modern neuro-histological technique; and complete sections through the cerebral hemispheres, or large portions of the central nervous system, had been used to elucidate the distribution of the patches. Although no complete interpretation of the subject could be given, or no uniform conception of the process offered, certain conclusions were formulated, of which the following may be noted. The process underlying disseminated sclerosis is a sub-acute disseminated encephalo-myelitis, which terminates in areas of actual and complete sclerosis. There is overwhelming evidence that the great majority of the areas arise on the basis of an evolution through a stage of fat granule cell formation. There is much to favour the

view that true disseminated sclerosis is due to a specific morbid agent, the nature of which is quite unknown. Histological evidence suggests a soluble toxin, conveyed to the nervous tissues by the blood channel rather than by lymphatics. The fleeting early motor paralysis and psychical symptoms may be related to the presence of areas in association paths, their remission being possibly due to the linking up of other association paths, or their compensation to the opening up of new paths. Although approximate answers may be given to questions relating to the nature of the process, to its origin, and to certain aspects of the mode of action, we are still quite in the dark concerning the nature of the final causal agent, which determines a disease which, however variable the early symptoms, conceals its characteristic course only temporarily.

February 15.—Dr. Peach, vice-president, in the chair.—Dr. H. **Rainy** and Dr. J. W. **Ballantyne**: Skiagraphic researches in teratology. The paper dealt with the abnormal development of bones in the human fœtus, and was illustrated by a number of X-ray photographs of these abnormalities. The facts brought forward opened up important questions in heredity, as well as in development.—Prof. J. **Stephenson**: (1) On *Haemonais laurentii*, a representative of a little-known genus of Naididæ; (2) on a rule of proportion observed in the Setæ of certain Naididæ; (3) on the sexual phase in certain of the Naididæ. An account was given in these connected papers of the various systems of organs and of the process of fission in this group of worms. A curious feature in two of the species described was the degeneration of the alimentary canal as the worm approached sexual maturity. Dr. F. R. Cowper **Reed**: The Ordovician and Silurian Brachiopoda of the Girvan District. In this elaborate memoir about 250 species and varieties were described, of which some seventy were new to science. The greater number of specimens described were from the collection made by Mrs. Robert Gray of Edinburgh, and with these were joined specimens from various museums in Great Britain. The local facies of the fauna were strongly marked; but many of the species, particularly those of Ordovician age, resembled American rather than European types. A characteristic feature was the limitation of distinctive species to successive stratigraphical horizons, a fact which suggested a more extended use of brachiopods for zonal purposes.

PARIS.

Academy of Sciences, February 15.—M. Ed. Perrier in the chair.—L. E. **Bertin**: The transport of marine mines by currents under the action of the ground-swell. The upward thrust on the mine due to hydrostatic pressure has been usually calculated from the value in water at rest. The alterations in the thrust due to an oscillatory motion of the water are calculated, and it is shown that to prevent the anchor being lifted its customary weight should be doubled.—C. **Guichard**: Surfaces such that the lines of curvature correspond on the primitive surface, and on the surface locus of the centres of the spheres osculating the lines of curvature of a series of the primitive surface.—Paul **Vuillemin**: The flower. A discussion of the flower in its relation to the leaves.—B. **Jekhowsky**: Observations of Delavan's comet, 1913*f*, made at the Observatory of Paris. Four positions given for January 8 and 11. The comet appeared as a rounded nebulosity of about 30″ diameter with a semi-stellar nucleus. Magnitude 7·5 to 8. No tail.—M. **Alezais**: A property of arithmetical progressions.—M. **Globa-Mikhailenko**: Ellipsoidal figures of equilibrium of a fluid mass in rotation when capillary pressure is taken into account. It is shown that the only ellipsoidal figure of equilibrium assumed by a fluid mass in rotation, if the surface tension is taken into account, is the cylinder of revolution.—A. **Guillet**: Wheel with harmonic teeth, application to the construction of a laboratory chronometer with a uniform and continuous movement.—E. **Mathias**, H. Kamerlingh **Onnes**, and C. A. **Crommelin**: The rectilinear diameter of nitrogen. The densities of liquid nitrogen and its saturated vapour were determined at temperatures ranging from −208·36° C. to −148·08° C., and the values of the ordinate of the diameter were found to be $y=0{\cdot}022904-0{\cdot}0019577\,\theta$. The angular coefficient of the diameter is $\alpha=-0{\cdot}0019577$, and the critical density $\Delta=0{\cdot}31096$. The critical coefficient $\frac{R\Theta\Delta}{\pi}$ is 3·421, or nearly the same as argon (3·424) and oxygen (3·419).—L. **Bouchet**: The deformation of vulcanised indiarubber under the action of an electrostatic field. The variable electrostatic pressures are sufficient to account for the observed facts without any additional hypothesis.—Keivin **Burns**: Interferential measurements of wave-lengths in the ultra-violet part of the iron spectrum Data are given for wave-lengths between 2851 and 3701 on the basis of the value 6438.4696 for the red cadmium line.—Henry **Hubert**: Preliminary sketch of the geology of the Ivory Coast.—B. **Galitzine**: The earthquake in Italy on January 13, 1915. Particulars of the records on the seismographs at the Pulkovo Observatory. The position of the epicentre calculated from the seismograms coincided very closely with the region of greatest damage, and it is pointed out that observations from a single station were sufficient for this determination.—Ph. **Flajolet**: Disturbances of the magnetic declination at Lyons (Saint-Genis-Laval) during the second quarter of 1914.—Henri **Coupin**: A marine yeast. The first example of a yeast isolated from sea water, for which the name *Torula marina* is proposed.—M. **Coquidé**: Remark on the nitrification in the peaty soils in the neighbourhood of Laon. The experiments were made on virgin soil and included the addition of potassium chloride or kainit, sodium nitrate, and phosphate slag, the three types being used separately, in pairs, or all together, the last giving the best results. The effect of omitting nitrate was marked, and there appears to be little or no natural nitrification of the nitrogenous material in these soils.—J. **Bergonié**: The mobilisation in the tissues of magnetic projectiles by the repeated application of electromagnetism. To move deeply-seated metallic fragments repeated applications of an electromagnet may be required, leading ultimately to a swelling on the surface exactly localising the fragment, and permitting its easy extraction by a simple operation. Details of cases are given in which the original position of the piece of shell was too deep-seated for direct removal, or in which unsuccessful operations after X-ray localisation had been made.—Raoul **Bayeux**: The treatment of hydrarthosis and hæmarthrosis by intra-articular pneumatic compression by means of oxygen.—A. **Pezard**: The experimental transformation of the secondary sexual characters in the Gallinaceæ.—A. **Sartory**, L. **Spillmann**, and Ph. **Lasseur**: Contribution to the study of typhoid states. Although the causal origin of typhoid fever is the Eberth bacillus, it appears to be probable that the pathogenic power of this organism may be increased by the presence of other micro-organisms, such as *Proteus vulgaris*, a diplococcus described by the authors, and possibly other pathogenic species. It is also possible that life in the trenches may give rise to a new clinical type of typhoid fever.

February 22.—M. Ed. Perrier in the chair.—The president announced the death of E. H. Amagat, a member of the academy in the section of physics.—G. **Mittag-Leffler**: A new theorem in the theory of the series of Dirichlet.—J. **Tavani**: The integral $\Gamma(\rho)$ and its relations with other definite integrals.—Marcel **Baudouin**: The discovery and excavation of a menhir found upright and completely buried in a marine alluvium on the coasts of Vendée.—V. **Lubimenko**: New researches on the pigments of the Chromoleucites.—D. **Olaru**: The favourable action of manganese on the bacteria of the leguminosæ.—Louis **Roule**: A new genus of apodal fishes, and some peculiarities of the biology of these creatures.—G. **Daumézon**: The potato as an agent of dissemination of Friedländer's pneumobacillus in nature, and especially in water.

BOOKS RECEIVED.

Indian Museum. Annual Report, April, 1913, to March, 1914. (Calcutta: Indian Museum.)

Bulletin de l'Institut Aérodynamique de Koutchino. Fasc. v. Pp. 296. (Moscou: I. N. Kouchnéreff et Cie.)

Soil Conditions and Plant Growth. By Dr. E. J. Russell. New edition. Pp. viii+190. (London: Longmans and Co.) 5*s.* net.

The Carnegie Trust for the Universities of Scotland. Thirteenth Annual Report (for the year 1913–14). Pp. 87. (Edinburgh: T. and A. Constable.)

Practical Science and Mathematics for the Second Year Preliminary Technical or Industrial Course. By E. J. Edwards and M. J. Tickle. Pp. viii+175. (London: G. Routledge and Sons, Ltd.) 1*s.* 6*d.* net.

DIARY OF SOCIETIES.

THURSDAY, MARCH 4.

ROYAL SOCIETY, at 4.30.—A Bolometric Method of Determining the Efficiency of Radiating Bodies: Prof. W. A. Bone, Prof. H. L. Callendar, and H. J. Yates.—The Simplification of the Arithmetical Processes of Involution and Evolution: E. Chappell.—The Elastic Properties of Steel at Moderately High Temperatures: F. E. Rowett.—The Laws of Series Spectra: Prof. J. W. Nicholson.

ROYAL INSTITUTION, at 3.—Poetry and War: Sir Herbert Warren.

ROYAL GEOGRAPHICAL SOCIETY, at 5.—Suess's Classification of the Eurasian Mountains: Prof. J. W. Gregory.

LINNEAN SOCIETY, at 5.—The Lichens of South Lancashire: J. A. Wheldon and W. G. Travis.—The Germination of Marah (*Echinocystis Marah*, Cogn.): A. W. Hill.—New Types of Stem-anatomy in Cycadeoidea, and a well-petrified new Species: Dr. Marie Stopes.—Description of a new Genus and Species of Terrestrial Isopoda from British Guiana: W. E. Collinge.

FRIDAY, MARCH 5.

ROYAL INSTITUTION, at 9.—Mimicry and Butterflies: Prof. E. B. Poulton.

GEOLOGISTS' ASSOCIATION, at 8.—Geology of the Glasgow District: Prof. J. W. Gregory.

SATURDAY, MARCH 6.

ROYAL INSTITUTION, at 3.—Recent Researches on Atoms and Ions: Sir J. J. Thomson.

MONDAY, MARCH 8.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Our Fisheries and their Geography: Prof. Stanley Gardiner.

TUESDAY, MARCH 9.

ROYAL INSTITUTION, at 3.—Photography in Natural Colours: Prof. W. J. Pope.

ZOOLOGICAL SOCIETY, at 5.30.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Improvement of the River Clyde and Harbour of Glasgow, 1873–1914: Sir Thomas Mason.

WIRELESS SOCIETY, at 8.—Waves: Dr. J. Erskine-Murray.

WEDNESDAY, MARCH 10.

ROYAL SOCIETY OF ARTS, at 8.—Patent Law Reform and the War: J. W. Gordon.

GEOLOGICAL SOCIETY, at 8.—The Plants of the Late Glacial Deposits of the Lea Valley: Clement Reid.—The Genus Lonsdaleia and *Dibunophyllum rugosum* (McCoy); S. Smith.

THURSDAY, MARCH 11.

ROYAL SOCIETY, at 4.30.—*Probable Papers*: Contributions to the Study of the Bionomics and Reproductive Processes of the Foraminifera: E. Heron-Allen.—The Occurrence of an Intracranial Ganglion upon the Oculomotor Nerve in Scyllium Canicula, with a suggestion as to its Bearing upon the question of the Segmental Value of certain of the Cranial Nerves: G. E. Nicholls.—Experiments on the Restoration of Paralysed Muscles by Means of Nerve Anastomosis. Part III. Anastomosis of the Brachial Plexus with a consideration of the Distribution of its Roots: Prof. R. Kennedy.—On the Mechanism of the Cardiac Valves. A Preliminary Communication: A. F. S. Kent.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Electric Cooking, mainly from the Consumer's Point of View: W. R. Cooper.

CHILD STUDY SOCIETY, at 6.—*Discussion*: The Care and Development of the Child—during School Age.—Treatment Centres and their Possibilities: Miss Margaret McMillan.—Care Committees: Mrs. Evelyn.

FRIDAY, MARCH 12.

ROYAL INSTITUTION, at 9.—Back to Lister: Sir R. J. Godlee.

PHYSICAL SOCIETY, at 8.—(1) The Estimation of High Temperatures by the Method of Colour Identity: (2) The Unit of Candle-power in White Light: C. C. Paterson and B. P. Dudding.—The Relative Losses in Dielectrics in Equivalent Electric Fields, Steady and Alternating (R.M.S.): G. L. Addenbrooke.

MALACOLOGICAL SOCIETY, at 8.—*Helicella crayfordensis*, n.sp. from the Pleistocene deposits of S.E. England: A. S. Kennard and B. B. Woodward.—Further Notes on Radulæ: the Rev. E. W. Bowell.—The Editions of Swainson's "Exotic Conchology": A. Reynell.

ROYAL ASTRONOMICAL SOCIETY, at 5.

SATURDAY, MARCH 13.

ROYAL INSTITUTION, at 3.—Recent Researches on Atoms and Ions: Sir J. J. Thomson.

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